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Chronicle and Comment

Hearing on Sections Matters

OVER 20 members attended the hearing held at the office of the Society in New York City last month by the Special Committee on Society and Sections Organization and the Sections Committee. Among those present were Past-President Bachman, chairman of the special committee; H. W. Slauson, chairman of the Sections Committee; T. J. Lítle, Jr., chairman of the Detroit Section and a member of the special committee; J. H. Hunt, member of the special committee; F. F. Chandler and George Briggs, chairman and secretary respectively of the Indiana Section; G. Walker Gilmer, Jr., treasurer of the Pennsylvania Section; O. A. Parker, vice-chairman of the Cleveland Section; Cornelius T. Myers and C. B. Veal, chairman and treasurer respectively of the Metropolitan Section; Milton Tibbetts, treasurer of the Detroit Section; and W. C. Ware, second vice-president of the Society.

In opening the meeting, Chairman Bachman stated that in the original establishment of geographical Sections of the Society many years ago, methods and precedents of older engineering societies, and particularly of the American Society of Mechanical Engineers, had been followed. This involved procedure on the basis that the Sections should be largely self-sustaining and independent in action, aside from the fact, of course, that the Sections are established by action of the Council of the Society under specified regulations. However, the amount of money appropriated from year to year from the treasury of the Society to support the Sections has increased steadily. After outlining the limitations and fluctuations of the annual income of the Society, Mr. Bachman gave a brief summary of leading features of the past experience of the Sections and stated that the Special Committee had been proceeding on the assumption that improved conditions are requisite with respect to the conduct and support of the Sections.

Section Associates

Mr. Lítle said that in his opinion the success of a Section depends purely upon the staging of interesting meetings for its members. The Detroit Section is now holding two meetings a month, alternate meetings being devoted to production subjects. He said that no Section should have any difficulty in deciding upon interesting subjects for discussion. The majority of those attending Detroit Section meetings on the average are not members of the Society. Many of these are young men and are prospective members. Mr. Lítle said that frequent visitors of this kind should be permitted to become affiliated with the Section by the payment of a fee but that they should not have any other privileges in the Section or the Society. Under such a system the Section meetings would be restricted to members thereof, the local affiliates and those receiving guest cards through Section members.

Chairman Myers, of the Metropolitan Section, said that the idea of the Metropolitan Section is not to enroll as local affiliates men who are eligible for membership in the Society, but garage mechanics or assistants and men engaged by operating companies. New York City is an operating and not a manufacturing center. Chairman Bachman said that he had never favored the enrolling of Section Associates for the purpose of producing revenue for the Sections. He pointed out that the sentiment on various Section matters that have been under discussion recently changes from year to year so far as the Governing Committees of the same Section are concerned. Mr. Myers felt that more continuity in office of Governing Committee members and of the policies of the Sections than exists at the present time would be very desirable. A major problem in the Metropolitan Section has been to meet the condition in which non-members of the Section, who do not contribute directly to its expenses, attend meetings of the Section from time to time over a long period of years. It is felt that this is unfair to the Section members.

Conduct of Sections

Chairman Chandler, of the Indiana Section, said that the officers of that Section had set for themselves the definite problem of doing considerable work by way of rendering the Indiana Section the kind of executive service they feel it deserves. He said that the solution of various problems of the Section lies in the selection of the right type of Section officers. If the right kind of Section meetings are held, the Sections will secure all the revenue they are entitled to.

Secretary Briggs, of the Indiana Section, argued that it is the duty of the Society to list early each year a long

list of subjects that would be of interest for discussion at Section meetings. He also emphasized the importance of effective publicity methods in connection with Section meetings. He felt that the desirability of enrolling local affiliates depends upon the conditions in the respective districts of the Sections. Each Section should prepare a yearly budget.

O. A. Parker, vice-chairman of the Cleveland Section, reported that this Section would not take advantage of a provision authorizing the enrollment of Section Associates, as it is felt that it is best to allow anybody to come to the meetings, and, moreover, that the parent Society will be benefited most in the long run by having no "introductory" form of membership. The Cleveland Section feels that no "deadheads" attend its meetings. All are welcome. Mr. Parker said that more continuity in Section office-holding would be very helpful. Mr. Parker was strongly in favor of having the Sections dues collected through the office of the Society.

O. M. Burkhardt stated that, judging from his experience as an officer of the Buffalo Section, it is highly desirable that a clear-cut policy with regard to the Sections be established. Section officers should know just what they ought to do. The Society should assist the Sections in arranging their programs.

Treasurer Veal, of the Metropolitan Section, expressed the opinion that the fundamental thing is to promote the parent organization. He related the experience of the Metropolitan Section in charging non-members an attendance fee at its meetings and in sending out "newspaper" publicity. He felt that the best thing a Section can do is to put on good meetings, avoid too much publicity and get a good crowd. He saw no advantage to the Society in the enrolling of Section Associates. He said that he would prefer to have men attend Section meetings without cost for 3 years and then become members of the Society rather than have them be Section Associates for life.

National and Local Relations

Chairman Bachman said that he gathered from the discussion that it was the sense of the meeting that the rules should be revised to provide for greater continuity of office-holding in Sections and a more intimate connection between the Council of the Society and the Governing Committees of the Sections. About 3500 of the 5000 members of the Society reside in Sections districts now as determined by the Council.

Raising Society Dues

Mr. Lítle opposed raising the annual dues of the Society or compelling a Society member to pay dues for a Section in which he is not interested. The Sections have never had larger balances in the bank than they have at the present time. It is doubtful whether compulsory or "adjusted" Sections dues would increase attendance at Sections meetings. Perhaps the main question is, should the man who does not support the Section be assessed?

Mr. Hunt said that if the Society should assume the responsibility of collecting Sections dues from all Society members residing in Sections areas, it would be responsible for the conduct of the Sections; whereas, if the Society office should simply assist in the collection of Sections dues from voluntary Section members, the Society would not assume the same responsibility. Mr. Myers stated that in the Metropolitan Section the officers are heavily burdened with the collection of dues, while many men who are well able to pay the dues and would pay them if the Section dues were a part of the Society dues, say they will attend only a few Section meetings a year and that it is not worthwhile to pay dues to the Section. They should support the Section because it is furnishing "the main part of the menu." This is a general condition that the Society must face.

W. E. Williams expressed the opinion that it is not fair for Society members, who do not attend Section meetings or pay Section dues, to get the benefit in The Journal of papers and discussions presented at Sections meetings, as well as of the hard work of the Sections. They should pay for what they get. Section dues should be added to the Society dues.

Mr. Veal advocated that the Society collect the dues of Sections members and urge other Society members residing in Section territories, who might reasonably be expected to join the respective Sections, that they pay Section dues. Fundamentally, it is up to a Section to sell itself.

Conference on Head-Lamp Illumination

At the instance of J. W. Lord, chairman of the Metropolitan Section Committee appointed at the request of the Society, an important conference was held in New York City last month for the purpose of securing better automobile head-lamp illumination. The following organizations, in addition to the Society, were represented at the meeting:

Automobile Club of New York
Automobile Merchants Association
Automobile Service Association of Manhattan
Automotive Electric Service Association
Bureau of Standards
Illuminating Engineering Society
Motor & Accessory Manufacturers Association
National Automobile Association
National Automobile Chamber of Commerce

It is important that the owners of new cars understand what constitutes desirable head-lamp illumination and that all garages install focusing diagrams. Copies of adjustment instructions, prepared by R. E. Carlson, of the Bureau of Standards, and printed by the National Automobile Chamber of Commerce, for wide distribution, were submitted for comment. P. J. Durham, president of the Automotive Electric Service Association, distributed copies of the chart at a meeting of that association held in New York City last month, and planned to send copies to all of its stations in this Country, these numbering over 2000. It was decided that a similar distribution should be made among the automobile dealers of New York City and the members of the National Automobile Chamber of Commerce. The general subject was discussed at the meeting of the National Automobile Dealers Association held in New York City last month. The Automobile Club of New York agreed to take the matter up with its members. Plans were made to confer with the American Petroleum Institute in regard to installing suitable head-lamp focusing charts at gasoline filling-stations. General Manager Heminway of the Motor & Accessory Association said that he would address a letter to the head-lamp and lens manufacturers in reference to issuing proper instructions with their products.

This meeting may well serve as a model for similar sessions in other cities.

Four-Wheel Brakes

By HENRI PERROT[1]

ANNUAL MEETING PAPER

Illustrated with DRAWINGS

FOLLOWING a review of four-wheel-brake development, the author quotes from a scientific note relative to four-wheel-braking action on a car that is rounding a curve, published by the French Academy of Science, and the conclusion therefrom that front-wheel brakes have a direct retarding effect on the motion of translation but, in addition, a direct retarding effect upon the instantaneous motion of rotation of the car about its own center of gravity. Further, from another article, he quotes authority for the theoretical advantage of four-wheel brakes on heavy down-grades.

Subsequent to an amplified statement that satisfactory operation of a four-wheel-brake system, from the driver's viewpoint and with reference to pedal-travel and pedal-pressure, constitutes the real problem, comparisons are made between internal-expanding and external-contracting types and the servo-brake is discussed with special reference to the Perrot system. The advantages of the author's four-wheel-brake system are set forth specifically, brake-system design is discussed in general and comments are made upon brake-lining, front springs and various precautionary measures that must be incorporated. He explains his non-use of equalizers and cites seven specific important items that should govern all four-wheel-brake design, as well as stating his ideas regarding the future development of the motor-car chassis, as affected by the present trend of brake-system practice.

THIS paper begins with a review of four-wheel-brake development, starting with the experiments of the late P. L. Renouf, in England, in 1904. I believe Mr. Renouf's patent is almost basic; but it is a front-wheel and not a four-wheel-brake patent. The brakes were applied to the two front steering-wheels of a three-wheel vehicle, as shown in Fig. 1, and were operated by a cable that ran down into the king-pin over a pulley at the top. In 1906, Allen-Liversidge patented, in England, a front-wheel-brake system that was experimented with extensively in England between 1906 and 1909. This system was defective in several ways and passed out of use. In 1909, both the Perrot and the Isotta systems were evolved, both English patents covering the fundamentals that are used by these two systems today, except that the Isotta system made use of a vertical king-pin. The first application of front-wheel brakes was exhibited to the English public at the Olympia Show in 1910, where some half-dozen different makes of car having brakes on the front wheels were on view. The most notable examples were the Argyll cars with the Perrot system, the Crossley, Arrol-Johnston, Thames and others, with various modifications of the Allen-Liversidge patents. The construction of the Allen-Liversidge design was peculiar. The main brake-control passed through the king-pin, and the layout was such that torsion was set-up at certain times in a way that locked the steering. Obviously, this was wrong.

On all these cars the front-wheel brakes were applied by the pedal alone, the rear-wheel brakes being applied by the hand lever. With this layout it was very easy to lock the front wheels by the use of the pedal, and the

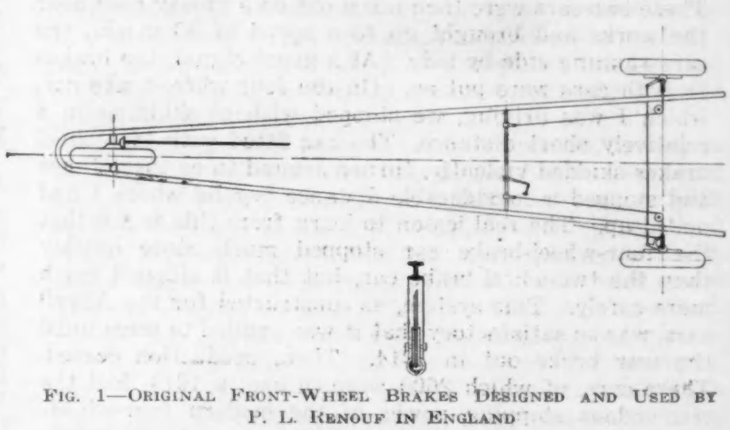

FIG. 1—ORIGINAL FRONT-WHEEL BRAKES DESIGNED AND USED BY P. L. RENOUF IN ENGLAND

The Brakes Were Applied to the Two Front Steering-Wheels of a Three-Wheel Vehicle and Were Operated by a Cable That Ran Down Into the King-Pin Over a Pulley at the Top. It Was a Front-Wheel and Not a Four-Wheel-Brake Design

rear wheels by using the hand lever, especially under greasy road conditions. Some accidents occurred, and manufacturers and drivers feared to use these brakes. As a result, except for the Argyll cars, the front-wheel brakes disappeared entirely from British cars. In 1912, the pedal and the hand lever were arranged so that they would both operate on all four brakes. Incorporated with this true four-wheel-brake system was the diagonal braking system that is well known to all automotive engineers from the discussion that has been in progress in this country for the past 2 or 3 years. This system, which is outlined in Fig. 2, employed one equalizer that equalized the braking pressure between the left-hand front and the right-hand rear, and between the right-hand front and the left-hand rear wheels respectively, there being no equalization between the diagonal wheels that were connected together. The primary reason for this diagonal braking was to comply with the English law that required two independent brakes. The layout was such that, if any one operating member broke, two brakes on diagonally opposite wheels of the car were still operative.

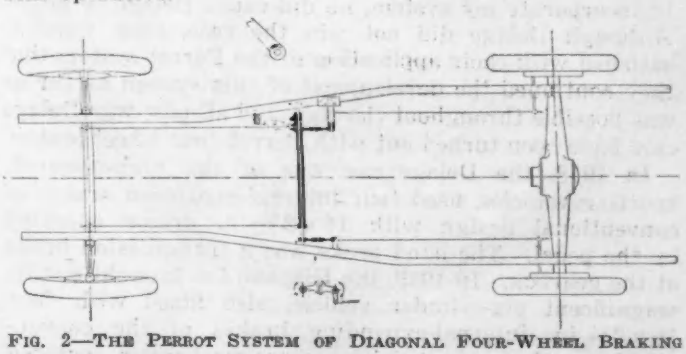

FIG. 2—THE PERROT SYSTEM OF DIAGONAL FOUR-WHEEL BRAKING

This System Employed One Equalizer That Equalized the Braking Pressure Between the Left-Hand Front and Right-Hand Rear and Between the Right-Hand Front and the Left-Hand Rear Wheels Respectively, There Being No Equalization Between the Diagonal Wheels That Were Connected Together. The Primary Reason for This Diagonal Braking Was To Comply with the English Law That Required Two Independent Brakes. The Layout Was Such That, If Any One Member Broke, Two Brakes on Diagonally Opposite Wheels of the Car Were Still Operative

[1] F.M.S.A.E.—Consulting engineer, Paris, France.

Application to Passenger Cars

In 1910, while chief engineer of the Argyll Co., I was developing my theories on four-wheel braking. I proved them out to my own satisfaction in actual practice, but it then became necessary for me to "sell" the directors of the company my ideas on this subject. With their consent, I fitted up two cars, one with standard two-wheel brakes and the other with four-wheel brakes. These two cars were then taken out on a greasy road near the works and brought up to a speed of 30 m.p.h., the cars running side by side. At a given signal, the brakes on both cars were put on. On the four-wheel-brake car, which I was driving, we stopped without skidding in a relatively short distance. The car fitted with two-wheel brakes skidded violently, turned around to or three times and stopped a considerable distance beyond where I had pulled up. The real lesson to learn from this is not that the four-wheel-brake car stopped much more quickly than the two-wheel-brake car, but that it stopped much more safely. This system, as constructed for the Argyll cars, was so satisfactory that it was applied to them until the war broke out in 1914. Then, production ceased. These cars, of which 2000 were in use in 1914, had the tremendous stopping power of the modern four-wheel-brake system, and a number of them are in use today. The reason for this great stopping power was because both the hand lever and the pedal could be used simultaneously to apply the brakes; so, while the brakes were somewhat inefficient, the final result was good. Today a number of these cars are still running well.

Application to Racing Cars

The first application of four-wheel brakes to racing cars was in the Grand Prix of Lyons in July, 1914. Four types of car among those entered were fitted with four-wheel brakes; Delage, Picard-Pictet and Fiat were fitted with the Perrot system. The late Georges Boillot, the best racing driver that France has ever produced and who, incidentally, was shot down during the war while flying, was really responsible for this development. He attended the Olympia Show in October, 1913, where the only four-wheel brakes on exhibition were those on the Argyll car. Being a friend of mine, he took advantage of this visit to try out the Perrot system of braking thoroughly. He was so convinced of its superiority that he wanted to incorporate it in the Peugeot racing cars which were then building for the 1914 Grand Prix. Unfortunately, he found that the front axle had already been constructed; so, although it was impossible for him to incorporate my system, he did cause Delage to do so. Although Delage did not win the race, they were so satisfied with their application of the Perrot system that they continued the development of this system as far as was possible throughout the war, and all post-war Delage cars have been turned out with Perrot four-wheel brakes.

In 1918, the Delage car, one of the high-powered, sporting vehicles, used four internal-expansion brakes of conventional design with 16 x 2½-in. drums operated by the pedal. The hand brake was a transmission brake at the gearbox. In 1919, the Hispano Co. brought out its magnificent six-cylinder vehicle, also fitted with four 16 x 2½-in. internal-expanding brakes of the conventional type but actuated by a servo-mechanism operated by the pedal. This development of the Birkigt servo-mechanism on the part of the Hispano Co. was due to the fact that it had experimented with a Delage car and found that the brake-pedal pressure required for efficient operation of the standard internal-expanding brakes under *extreme* conditions was excessive.

From 1920 on, the use of four-wheel brakes developed rapidly, first with the large cars, then with the medium and small cars and, in 1923, with the application of four-wheel brakes to taxicabs, jitneys and chars-a-banc. The latest development is that of one of the great French railroads, the P. L. M., which is buying only buses fitted with four-wheel brakes for all its Alpine touring vehicles. Switzerland has recently passed a law requiring four-wheel brakes on all cars, and this fact speaks for itself. This brief resume gives some idea of the amount of work that has been done on four-wheel brakes up to the present.

In September, 1923, Mons. P. Appell, the rector of the French Academy of Sciences, transmitted to the Academy for publication a short scientific note on four-wheel brakes. This note was prepared by Mons. A. Petot, a well-known French professor of engineering. The importance of a note accepted for publication by the Academy is well known and I venture to quote briefly from it. The title of the note is the Characteristic Difference Between the Action of the Front and the Rear-Wheel Brakes on a Car. The note itself considers particularly the effects while braking a car on a curve and reads in part as follows:

> It will be admitted that a car in motion on a curve is turning about an instantaneous center to one side of the car; and the center of gravity of the car is describing an arc of a circle about the same center. This motion of the center of gravity can be resolved into two motions; one is a motion of translation instantaneously through the center of gravity and parallel to the axis of the car, and the other is an instantaneous motion of rotation about the center of gravity of the car itself. Therefore, it will be seen that brakes have two functions; first, that of retarding the motion of translation of the entire mass considered as acting from the center of gravity and second the motion of rotation about the center of gravity. It now remains to be shown by what means these two functions are fulfilled.

M. Petot goes on to prove that brakes acting on the rear wheels on a curve operate to arrest the motion of translation only, and that motion of rotation is arrested only by the transverse adherence of the tires to the road. He evolves an equation for this which brings out the limits of two-wheel braking before skidding occurs. He then goes on to formulate another equation showing the effect of the front-wheel brakes and proves that they have a definite retarding effect on the motion of rotation as well as on the motion of translation. His conclusion, translated as nearly as may be, is as follows:

> Front-wheel brakes as well as rear-wheel brakes have a direct retarding effect on the motion of translation but, in addition, the front-wheel brakes have a direct retarding effect upon the instantaneous motion of rotation of the car about its own center of gravity.

M. Petot's conclusions are that the freedom from skidding and the like with four-wheel brakes is due to this front-wheel-brake effect.

I wish to call attention also to a short article entitled Braking Effects on Road Vehicles; the Case for the Four-Wheel Brake System[2], by F. A. Stepney Acres, This article, among other things, brings out theoretically the advantage of four-wheel brakes on heavy down-grades.

The Real Problem of Four-Wheel Brakes

This problem is one of obtaining satisfactory brake operation from the point of view of the driver, with two

[2] See *The Automobile Engineer*, August, 1918, p. 298.

limiting factors to be considered. These factors are, first, the pedal travel, which preferably should not be more than 5 in., of which one-half should be sufficient for full brake-operation when the car is newly adjusted and the other half of which should be available for wear prior to readjustment. The other factor is pedal pressure, which I believe should be limited to a maximum of 50 lb. under normal conditions. This means that not more than 50 lb. should be necessary for maximum braking under all ordinary conditions of road travel, though, at times, a possibility exists that somewhat more pressure might be necessary in an emergency. Too great pressure is very bad; but too light pressure is, I believe, worse in some ways because, under conditions of stress, the operator of the brake, especially with a power servo-mechanism, is likely to apply the brakes so hard as to decrease their effectiveness by locking the wheels. I am impressed by the desire of engineers in this Country to lock the wheels at relatively low pedal-pressures. I realize that this is due in a considerable degree to what is now a public demand, but I believe that the public should be educated out of what is an absolutely wrong idea.

W. S. James, of the Bureau of Standards, has published recently the results of some tests that are undoubtedly confusing. At the same time I am not yet altogether ready to give up my belief that, as applied to a tire rotating on the road against one skidding on the road, the friction of rest is greater than the friction of motion, which is apparently disproved by Mr. James' experiments. Certainly, my driving experience does not lead me to agree with this new theory and, entirely aside from which condition gives the greater braking effect, locking the wheels and skidding the tires is undoubtedly very bad for the tires themselves. One of the objects of four-wheel braking is to reduce tire wear. I am most interested in Mr. James' work, which is undoubtedly very carefully carried out, and believe that before long he will obtain results that will be a real asset to the automobile industry both in this Country and abroad. I understand that he includes among his objects the development of the proper test mechanism for the development of better brake-lining, as well as instruments for retardation tests to be used by the police authorities. I hope that it will be possible for him to continue his road-surface friction-tests to a point where such apparently contradictory results are cleared-up.

The Servo-Brake

I do not believe that the problem of four-wheel brakes can be solved with the conventional, internal-expanding brakes without some kind of servo-mechanism. The reason for this is that excessive pedal-pressure is required; or, if sufficient leverage is given to make the pedal-pressure reasonable, the pedal travel is too great or adjustment is required too frequently.

There are, as we know, several successful servo-mechanisms using power to apply the brakes, the brake-pedal being used simply as a means of actuating the servo-mechanism. The best known of these are the Birkigt on Hispano and Delage, the Hallot on Chenard-Walcker, and the Renault. The Birkigt and Renault types are nearly alike and an opportunity of inspecting the Renault type was afforded at the 1923 Semi-Annual Meeting of the Society at Spring Lake, N. J. The Hallot device is based on the use of centrifugal force; it claims to be a satisfactory device in giving maximum braking without locking the wheels. The Delage is an hydraulic servo-mechanism, the power of the hydraulic system being obtained by a gear pump in the transmission.

All these mechanisms are expensive and complicated, and I have felt that simpler methods of obtaining a result equally satisfactory to the driver should be provided. In the past 3 years, I have been working with the chief engineer of the Farman Co. in the development of a self-contained servo-brake. This brake, which is shown in Fig. 3, has been variously designated as an internal-expanding, self-wrapping or self-energizing brake, or as a self-contained servo-brake, any of these phrases being very descriptive. This brake is a most effective mechanism, and I have no hesitation in saying that it solves the problem of the direct pedal-operated four-wheel brake on the standard passenger-vehicle.

In developing this brake with my associates, we began by studying the self-wrapping internal-expanding-band brake. We tried this with not only full wraps but with various portions of the full wrap, developing the band from a thin steel band to one that was about 3/8 in. thick, which was found to be required so that the band would hold its circularity and relieve itself nearly automatically. This heavy type of band brake gave good results, but we found that we had lost most of the benefit of the self-wrapping feature owing to the relatively high pedal-pressure that was required to operate a steel ring of such thickness. The next step was to use two solid shoes with a hinge, practically the same as our present construction. A number of small details were found to be most important, and a considerable amount of development work was required before we knew the proper relative positions of the fixed point, the hinge point and the cam to get the best results.

Internal-Expanding versus External-Contracting Types

The same results that have been obtained with the Perrot-Farman servo-brakes can be obtained with ex-

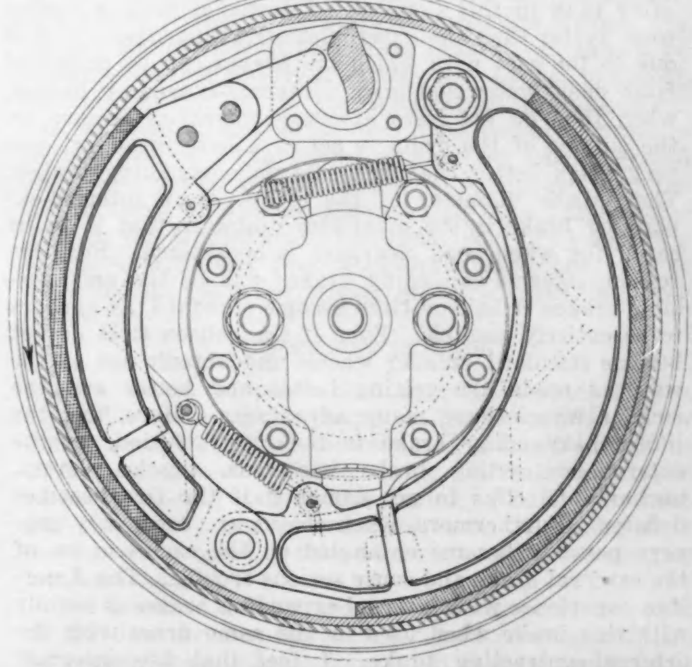

Fig. 3—The Perrot-Farman Self-Contained Servo-Brake
This Brake Has Been Designated an Internal-Expanding, Self-Wrapping or Self-Energizing Brake, or a Self-Contained Servo-Brake, But Any One of These Designations Is Fully Descriptive. Mr. Perrot Says This Brake Is a Most Effective Mechanism. One of the Final Points in Its Development Was the Use of Two Solid Shoes With a Hinge. A Considerable Amount of Development Work Was Required Before the Proper Relative Positions of the Fixed Point, the Hinge Point and the Cam Could Be Determined So As To Produce the Best Results

ternal-contracting brakes, especially when the latter are new. The external-contracting brake, which is essentially a band brake as at present produced, has a self-wrapping effect. This wrap can be made of almost any value to suit the conditions and, as a result, can produce a very effective brake. It will be asked why, therefore, the internal-expanding brakes are to be preferred. The reasons are that the external-contracting brake requires more clearance; that it is practically impossible to keep the bands truly circular; that, under varying conditions of heat, moisture and dirt, the action of these brakes varies greatly and that, when these brakes are made to be efficient, they appear to me to lock the wheels too easily. I also feel, from considerable experience with this type of brake, that the external-contracting brake does not allow of the progressive brake application from nothing to the maximum which is possible with the internal-expanding types.

Objections are raised to the internal-expanding types; first, that they have to be made more accurately. This is true. Less clearance is necessary to give good service, but the smaller tolerance can be obtained easily and inexpensively and the resulting mechanism is superior to the external brake, having much longer life between adjustments. I read recently in a well-known trade journal an article on the adjusting of the brakes on a well-known external-contracting four-wheel-brake system that was far from simple. By using internal-expanding servo-brakes, a single adjustment only is required and that on the lever on the controls. Practically the same adjustment can be arranged for internal-expanding brakes of the standard type on the rear, so that the driver has only to turn a simple wing-nut with his fingers to make the adjustment. This method is undoubtedly very much simpler than the methods that appear to be necessary in adjusting external-contracting brakes.

Maximum simplicity is the thing to aim for, even abroad, where cars are, I understand, much better looked after than in this Country. Internal-expanding brakes wear better than the external-contracting type. This is due to the ease with which the brakes can be protected from dust, water and mud. Internal-expanding brakes, when they do not have external-contracting brakes on the outside of the drum to act as a heat insulator, cool very much better than the external-contracting brakes. The outside diameter of the drum on an internal-expanding brake is the maximum diameter that is to be cared for when road clearance is considered. For this reason, internal-expanding brakes will be the only possible brakes if balloon tires become standard, as appears to be entirely possible. Even if the balloon tires do not become standard, smaller wheels undoubtedly are on the way, as roads are getting better and better and the smaller wheels have many advantages. Here, too, the internal-expanding brake is the only solution, as the external-contracting brake has rods, toggles, levers, anchors and clips to get damaged if the tire becomes deflated. Furthermore, when chains are used, they may very possibly become entangled on the excrescences of the external brake and cause serious trouble. The American experience with internal-expanding brakes is mainly with this brake when used on the same drum with the external-contracting brake. I feel that the internal-expanding brake, as used in America as an emergency brake, has had very little attention paid to it and, therefore, that the prejudice against this type of brake is due rather to inattention than to an objection to a thoroughly tried-out mechanism. At present, in Europe, no car is turned out with external-contracting brakes. It is true that greater leverage is necessary with the standard internal-expanding brake, but this leverage is allowable because of the much smaller clearances that can be used on this type because of its better protection and cooling.

Advantages of the Perrot Braking System

As to the advantages of my particular braking system, I am naturally thoroughly conversant with it and feel that some of its real merits have not been appreciated fully. Specifically these are:

(1) That braking effort has practically no effect on the steering, even when the brakes are out of adjustment. This is due to the use of inclined king-pins and approximate center-point steering
(2) The design of my controls allows practically any amount of steering-lock, without having constructional difficulties arise
(3) This system makes possible the differential action that slightly relieves the braking effort on the outside front-brake when turning a curve, thus assuring a rotating wheel at the most important point
(4) Owing to the fact that the brake mechanism is carried by the chassis up to a point opposite the brake cam, and the braking effort is taken across by a torque shaft, "fight" on the brake-pedal on rough roads is practically eliminated
(5) The brakes will continue to function even with a distorted axle or partly broken spring
(6) The layout of the design makes it possible to utilize any shape of cam, making the Perrot-Farman servo-brake, with its self-energizing shoes, easier of application
(7) The position of the brake mechanism is such that it is protected thoroughly from road inequalities
(8) The operating mechanism is totally enclosed in a very neat way, and one might say that it is equally clean in layout and in service

While I appreciate the tremendous difference between conditions in France and those in this Country, I do believe that a Perrot layout is being prepared for the American market which will be relatively inexpensive to manufacture and thoroughly satisfactory in service. Briefly, the methods by which I would obtain the above results are:

(1) Front brakes. Perrot-Farman servo-brakes. These can be made more simple and less expensive than the standard internal-expanding brake
(2) Perrot brake-controls, illustrated in Fig. 4. Basically, those which you have seen illustrated many times, but modified to make them inexpensive in production, although they are today even better than my latest French designs
(3) Special care will need to be exercised to see that the design of the internal-expanding brake is brought uptodate so that it may be effective. Clearances must be kept down. The cam must be constructed so as to assure the equal application of both shoes. This is something that is actually accomplished very seldom.
(4) The brake connections must be ample in size so that there shall be the minimum possible slack and spring to take-up. These connections may either be solid without equalizers and with really easy adjustment as close as possible to each brake, or they may be diagonal braking connections with the one equalizer thus necessitated and equally easy adjustments. Which of these should be used is a matter of judgment that can be worked-out for the individual case. The main thing to be brought out is the solidity of the connections and the reduction of the parts

to the minimum, so as to assure the highest possible mechanical efficiency from the brake-pedal to the actuating cam

With a layout such as this, I am convinced that it is entirely satisfactory to have four brakes only, operated on four separate drums and all operated by the brake-pedal. The hand brake is to be connected to the same shoes, either on all four or on the rear shoes. Such a layout is now the practice in Europe and is admitted to be in compliance with the law.

With the solid layout, it is possible to break the connections to three brake-drums and still have one brake acting. With the diagonal braking-layout, two brakes can be thrown out of commission and still have two brakes operating. With relatively simple stops on the equalizer, it would be possible to break three connections and still have braking effect on the fourth drum. This system, while it requires four brakes and not five or six, is certainly as effective as any other direct-action braking-system and, owing to its simplicity, undoubtedly is cheap to manufacture and light, especially in unsprung weight.

Brake-System Design

In designing a braking system for any car, a number of points must be taken into consideration, especially those that influence the selection of the material that is used. Brake-drums are very important. If an inexpensive brake-drum is not the prime object and the best is wanted, the die-cast aluminum-drum with a cast-iron liner undoubtedly is the most effective type that has been constructed uptodate. Aluminum has the heat-radiating ability, and the cast-iron liner is known to be the most perfect braking-surface. Care must be experienced, of course, to make the aluminum drum of the proper section, so that it will not distort and will dissipate heat quickly. If expense is a primary limit in manufacture, steel drums can be used satisfactorily; but they must be made of rather high-carbon steel and heat-treated, if long service is to be obtained from the brake fabric.

As I have stated before, my experience is almost entirely with European cars and, naturally, with European brake-lining. The standard Ferodo brake-lining, when used with steel drums having between 0.1 and 0.2 per cent of carbon, cuts the drums to pieces in very short time. As the carbon-content increases, the cutting grows less and, if a steel drum having from 0.35 per cent of carbon and upward be used, cutting will not occur and satisfactory results will be obtained.

Brake-Lining

Brake-linings are a problem. Ferodo is the lining that is most extensively used abroad, and may be considered as the European standard. At the time of writing this paper, I had not yet been able to gather complete information as to the merits and demerits of the various American linings. However, I would point out that linings for internal-expanding brakes should not be the same as those for external-contracting brakes, and must be made to suit the work that they are to do. On the best cars in Europe we are using Ferodo die-pressed brake-lining, and the surface of the lining is ground to size on a jig after it has been riveted to the shoes. I am told that much development work is being done on brake-linings in this Country, and I am sure that the problem either has been or will be solved shortly. The Bureau of Standards' work on brake-lining is of the utmost importance in the development of brake design, and it is to be

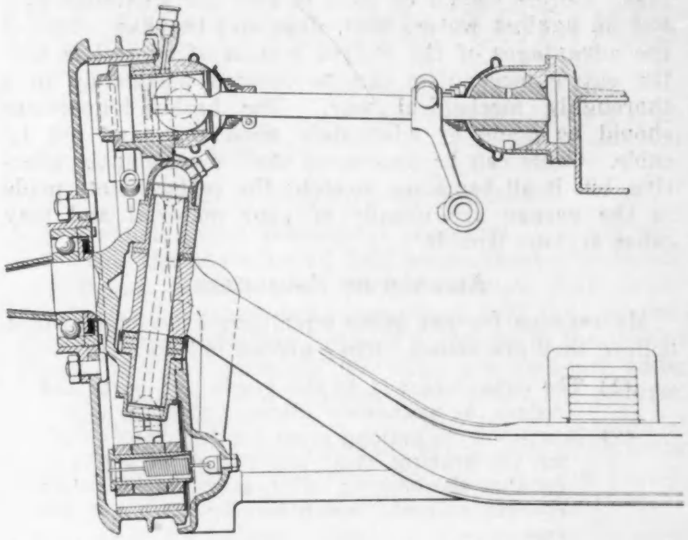

Fig. 4—Brake-Controls of the Perrot Four-Wheel Brake System

Due to the Use of Inclined King-Pins and Center-Point Steering, the Braking Effort Has Practically No Effect on the Steering. This Design Allows Practically Any Amount of Steering-Lock Without Causing Constructional Difficulties To Arise. The System Makes Possible the Differential Action That Slightly Relieves the Braking Effort on the Outside Front-Brake When Turning a Curve, Thus Assuring a Rotating Wheel at the Most Important Time

hoped that its work may be continued actively so that brake-lining manufacturers may be able to turn out a lining that will be entirely satisfactory. The successful type of brake-lining for a given drum material may not be at all successful with another type of drum maerial. The effect of Ferodo on steels of different carbon-content is a case in point.

Front Springs For Use With Four-Wheel Brakes

Front springs, when laid-out for four-wheel-brake cars, must be materially different from the springs for the car equipped with two-wheel brakes. It should be remembered that the front springs are obliged to absorb the torsion set up by the front-wheel braking-effect. For this reason, the spring-eyes must be made carefully and reinforced. The second leaf of the spring should be carried out to a point under the spring-eye, and the spring itself should be calculated to be a little stiffer than on the normal two-wheel-brake car. In comparing brakes on different four-wheel-brake cars, the rate of deflection of the front spring must be taken into consideration.

Precautions in Design

As a matter of precaution, with front-wheel brakes, a small stop should be placed on the lower side of the frame member back of the rear end of the front spring so that, in case of a broken spring, the backward travel of the front-axle body can be limited. The U-bolts holding the spring on the axle bed, and the spring-clips, must be redesigned to take care of the new stresses that are introduced.

The front axle itself must be redesigned to take care of the new stresses introduced. Inclined king-pins are, of course, absolutely necessary. It is now our practice in Europe to use an elliptical section from near the outside of the spring bed to the king-pin. It will be found that such an axle can be designed with a very small increase of weight, and is easier to forge than the standard H-section axle. The designer should take real precautions, as I have done, in protecting the brake-lining against oil from the king-pins and the axle bear-

ings. Covers should be built to give the maximum protection against water, mud, dust and the like. One of the advantages of the Perrot system of control is that the entire mechanism can be covered adequately in a thoroughly mechanical way. The brake connections should be made by adequately sized rods and not by cable. Cable can be purchased that is reasonably effective, but it all has some stretch; the replacements made in the garage are usually of poor material and may cause serious trouble.

Absence of Equalizers

My reasons for not using equalizers are simple, but I believe they are sound. They are as follows:

(1) The equalizers add to the number of parts and reduce the mechanical efficiency of the system

(2) Equalizers do nothing more nor less than equalize the braking *effort* and do not in any way equalize the braking *effect*, even provided they operate properly, which is very often not the case

(3) With four-wheel brakes, the braking effort is spread over at least twice as much braking surface and the wear is bound to be very much smaller; so, with easy adjustments on the brakes themselves, equalization is a useless added complication that seldom does any good

Important Items of Four-Wheel-Brake Design

There are many important items in the design of four-wheel brakes, and these items are less connected with the brake itself than with the front axle, the front springs, the steering linkage and the like. To assist in a proper understanding of this part of the problem, a few details are presented herewith as to points which should be watched carefully in making front-wheel-brake layouts:

(1) *King-Pin Angle.*—In some ways, the ideal would be a vertical king-pin in a centrally pivoted front-wheel. The drawback to this construction is the difficulty of overcoming wheel shimmy. As a matter of practical politics, the king-pin angle should be kept as small as possible so as to provide easy steering. For this reason, the disc wheel offers many advantages. On heavy vehicles the disc wheel is even more advisable as, if the king-pin is not nearly vertical, the steering becomes so heavy as to be laborious. If balloon tires become standard, the disc wheel will increase in popularity for the same reason

(2) *Maximum Distance of the King-Pin Center from the Intersection of the Center Plane of the Wheel with the Ground.*—These two lines should not intersect exactly for two reasons. First, because if they do intersect, it makes steering more difficult when the car is standing still, there being no relative rolling action set-up, and the plain twisting action is hard on the tires. Second, with true center-point steering, it is very difficult indeed to eliminate wheel wabble or shimmy at some or all speeds. The point of contact of the king-pin center-line with the road should be inside of the surface of tire contact

(3) *Castering Angle.*—One of the two most important points in connection with the difficulties arising in designing the steering-system, on cars fitted with front-wheel brakes, is the castering angle. There should be a slight castering angle to assist in the ease of steering, but this must be very small so as to avoid shimmy; its allowable amount will vary with the camber and the rate of deflection of the front springs

(4) *Influence of Steering-Gears on Steering.*—It has been my experience that it is more difficult to get really steady steering with the screw-and-nut type than with the worm-and-wheel type of steering-gear. I have had more difficulty in curing wheel wabble on cars that had the front axles fitted with ball bearings than when they were fitted with plain bearings. I have had no experience with the popular American types of tapered-roller bearing. Also, with plain bearings, a neater design of stub axle can be made and, usually, the king-pin angle can be lowered

(5) *Front Springs.*—The front springs should be as nearly flat as possible to give the best results. Only a slight camber is allowable. The front springs should be somewhat stiffer with the front-wheel-brake job than with the standard two-wheel-brake layout. With excessively soft springs, the slight caster that is advisable in any good design can be taken out completely with a severe application of the brakes, and an anti-castering action may be introduced. The result of such an anti-castering action is fatal to the steering-system of a car

(6) *Influence of Front-Wheel Brakes and Balloon Tires on Steering.*—This influence is a very considerable one and necessitates a much more careful study of the steering-gear itself, on account of the small extra resistance set-up by proper front-wheel brakes and the much greater resistance set-up by balloon tires. Putting it briefly, four-wheel brakes and balloon tires will necessitate new steering-gears

(7) *Test for Quality of Front-Wheel Braking.*—On any new type of car, the easiest way to prove or disprove the quality of the front-wheel braking system combined with the steering, springing and the like, is to take off all the brakes except one front-wheel brake and test the car with this one front-brake in action. If the layout is right it will be perfectly possible to apply the brake fairly hard with only a slight pull on the steering-wheel

Future Development

Usually, a prophet has to eat his own words after a period; however, you may be interested in my ideas as to the probable direction of development of the motor-car chassis, especially as this is affected by the present-day development in brakes. First, I believe that we will revise our front spring-suspension entirely. I know of a considerable amount of experimental work now going on, and this is directly due to the new problems set-up by four-wheel brakes. Second, I believe that a very considerable modification will be made in the design of the front and the rear wheels. This is due to the appearance of the balloon tire and the success of the disc wheel.

In conclusion, I want to thank the gentlemen here present as well as the host of friends I have made in the United States for my reception. I came over here because I felt that four-wheel brakes had made their place in Europe and had definitely come to stay in the United States. I wanted, therefore, to be sure that some responsible organization should make the best use of my work and experience of the past 14 years. I certainly do not feel that I know all about four-wheel brakes and, constantly, I see possibilities of improvement. I do believe, however, that the 70 different makes of car, some of which have been on the road for more than 10 years with the Perrot mechanism, have taught me something, and I am only too glad to have been able to put the results of some of this experience before you.

The Field and Future of the Motorbus

By J. A. Emery[1]

Annual Meeting Paper

MOTORBUS development in territory not served by railroads and as a substitute for or a supplement to railroads in other sections, is discussed. As the number of miles of surfaced highways in the United States at the present time is nearly 50 per cent greater than the total mileage of the railroad lines and about 2,500,000 miles of unsurfaced highways are available, the motorbus has open to it an enormous non-competitive field. Among the advantages of the bus are the low investment required and flexibility of operation. It is shown, on the other hand, that due to changes in conditions since 1910, to invite the construction of railroad lines, about four times the anticipated gross revenue is now required and about 2½ times as much traffic is necessary to produce the same operating revenue as was the case at that time. Electric railways demand a density of population of 1500 per mile of track for profitable operation, whereas one-sixth this amount is ample for motorbuses running on an hourly schedule.

As an adjunct to railroads the principal function of the bus is as a feeder in widening the available tributary territory. While the outskirts of a city are building up, transportation must be provided, and this can be offered better by the bus than by the railway because of the high cost of street-railway construction. Twelve hundred buses, more than one-half of which were ordered in 1923, are said to be in operation in connection with 121 of the 820 electric railways in the United States. Owing to the changing conditions, many electric railway lines have become unprofitable; on these the bus could be substituted to advantage, at least when replacements become necessary. The operating expenses of the bus and of the electric car are about equal, but the amount necessary for return on investment is from three to six times greater, dependent upon the density of traffic.

The usefulness of the railroad has been increased tenfold within the last 100 years by the invention of the telegraph, the Bessemer-steel rail and the airbrake; the efficiency of electric railway operation has likewise improved very greatly as exemplified by the progressive changes in powerplant apparatus and practice. In view of the rapid development in the efficiency of automotive vehicles within the last 10 years, it is probable that the progress of the bus industry will surpass that of steam and electric railways. Efforts must be directed toward producing comfortable vehicles with the maximum carrying-capacity, keeping the maintenance costs within bounds, operating economically and rendering reliable service. Body design seems to offer the greatest opportunity for improvement. The industry must profit by the experience of street railways and not extend fare zones to the point at which future profits will be compromised, and at the same time it must keep in mind the fact that high fares cut down the riding habit. As streets become more congested, it is probable that the use of buses will be encouraged over that of private cars because of the bus' greater carrying-capacity.

THE phenomenal spread of the motorbus proves that a wide and necessitous field was awaiting it. This field may be divided with respect to the relation of buses to railroads as follows: (*a*) on routes not served by railroads, (*b*) as an adjunct to railroads on routes now served by them and (*c*) as a substitute for railroads on unprofitable routes.

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Routes Not Served by Railroads

The small initial investment necessary for bus service gives the bus a broad field where the traffic is not of sufficient density to support a railway. This is by far the greatest and most important field for the bus. There are over 2,900,000 miles of highways in the United States, of which about 430,000 miles are surfaced, while the total railroad line mileage, both steam and electric, is only about 300,000.

It can hardly be expected that every mile of highway will ever support a motorbus line, but the low investment and the flexibility of the motorbus open to it an enormous non-competitive field. This field has been broadened by reason of the slowing up in steam-railroad construction since 1910. Due largely to the effects of drastic regulation, steam railroad additions fell off from a rate of 4700 miles of line per year previous to 1910 to 2700 miles per year between 1910 and 1915. Since 1915, due principally to the war, new construction has dropped to less than 500 miles per year and a net loss of about 3000 miles has been recorded. Thus, although the population of the United States has increased 18 per cent since 1910, steam-railroad mileage has increased only 4 per cent, and to give the same mileage per 1000 population in 1923 as in 1910, it would be necessary to build 35,000 miles.

TABLE 1—APPROXIMATE NECESSARY RETURN PER MILE ON CAPITAL FOR THE CONSTRUCTION AND THE EQUIPMENT OF STEAM-RAILROAD EXTENSIONS

	1910	1922
Capital Cost	$50,000	$87,500
Minimum Necessary Rate of Return, per cent	6	7
Minimum Necessary Return	$3,000	$6,125
Gross Operating Revenue	$1.00	$1.58
Operating Expenses and Taxes	$0.70	$1.34
Net Operating Revenue	$0.30	$0.24
Net Operating Revenue per $1 of Gross Revenue	$0.30	$0.15

But the difficulty of catching up in railroad construction is multiplied by the factors of cost. It costs approximately 75 per cent more to build and equip railroad lines now than it did in 1910; although rates are about 58 per cent higher on the average, the cost of operation for the same volume of traffic is about 90 per cent greater. Thus, while the fixed charges per mile are over twice as high, the net earnings are less on the same volume of traffic.

This is illustrated by the example given in Table 1.

TABLE 2—GROSS REVENUE NECESSARY TO SUPPORT 1 MILE OF AVERAGE STEAM-RAILROAD EXTENSION

	1910	1922
Minimum Necessary Return	$3,000	$6,125
Net Operating Revenue per $1 of Gross Revenue	$0.30	$0.15
Necessary Gross Revenue	$10,000	$40,830

Combining the foregoing figures the comparative gross revenue necessary to support an average steam-railroad extension per mile is given in Table 2.

Thus four times the gross revenue is now required to invite the construction of an extension. If this be translated into terms of traffic, by dividing the 1922 figure by the ratio of the average rate in 1922 to the average rate in 1910, namely, 1.58, it is found that over two and one-half times as much traffic is now required as in 1910, to produce the same operating revenue.

Naturally the higher rates now in force are a deterrent to traffic so that even if automotive competition had not appeared, the further extension of land transportation facilities by the steam railroad would have been much restricted.

This situation is much more aggravated in the case of the electric railways, and extension work has been reduced from about 1300 miles per year in 1910 to an average of approximately 200 miles per year in the last 4 years. These later extensions have been more than offset by abandonments. At the rate of construction before 1910, the railroads, both steam and electric, are 7 years behind in the ratio of mileage to population that they bore in 1910, and there would be little hope of their catching up in the future, even if there were no motorbus competition.

Except under very favorable circumstances, an electric railway can hardly be built if the density of population is less than 1500 per mile of track. But a single motorbus can be operated on a 1-hr. headway if the population is not over 250 per mile. For a 2-hr. headway 125 per mile will suffice, and the field for still less frequent headways such as those of stage-coach service is enormous.

The rise of city planning in this Country has laid the foundation for a great development of boulevard or parkway systems in urban centers. Electric railways are entirely unsuited to transportation service on such thoroughfares, yet service is needed not only for the population that settles along them, but to enable the population at large to obtain the privileges and benefits of such civic improvements. The comparatively noiseless, attractive and non-obstructive modern bus has none of the objectionable features of railways, and as new residence streets build up, calling for more transportation service, the motorbus is certain to be preferred to extensions of electric railways.

For hotels, schools and special touring or sight-seeing routes, the motorbus has become indispensable. Good service and adequate advertising should result in vastly enlarging these classes of service.

As an Adjunct to Railways

As an adjunct to the railway, the first and much the most important function of the motorbus is as a feeder. The financial success of the railway depends upon density of traffic. The motorbus greatly widens the area tributary to a railway. If the effective area or the width of the tributary territory served depends upon the time of transit, the motorbus will bring three times as much territory within reach of the railway as did horse-drawn vehicles.

By extending accessible areas the automobile has greatly increased freight movement. The motorbus, as one important form of the automobile, plays its part in this development. Comparing 1923 with 1910, the passenger-miles traveled per capita on the steam railroads in the United States is about 3 per cent greater than in 1910, but the revenue ton-miles of freight carried per capita has increased 40 per cent.

Whether or not the railroad operates its own motorbus feeders, they are valuable adjuncts. Wide-awake railway managements possibly will find many places where motorbuses would not pay independent operators, but where the railroad could afford to establish or subsidize motorbus lines to secure long-distance passengers.

The motorbus feeder should become a very important feature of street-railway systems. Urban population in the United States is increasing much faster than that of the Country as a whole. New building developments are rife in all live cities and as houses go up in the outskirts of a city, transportation facilities must be provided to serve them. The high cost of construction and operation makes it impossible to extend street railways in outlying districts except under exceptionally favorable circumstances. The solution in such cases lies in the motorbus.

Other purposes or uses for which the motorbus may become a valuable adjunct to the railway are

(1) To provide a combination express and local service
(2) To help handle rush-hour traffic
(3) To supplement the service on single-track lines where the traffic has outgrown a single track
(4) To provide differential service by charging higher fares and giving a higher quality of service than is offered on the railway lines, as, for example, providing a seat for every passenger
(5) For special routes and occasions where the railway lines are not convenient
(6) As a flexible emergency squadron

One hundred and twenty-one electric railways out of 820 in the United States now have over 1200 motorbuses in operation or on order, more than half this number having been ordered in 1923. The electric railways have a total of 83,000 passenger cars.

Substitute for Unprofitable Railway Lines

As a substitute for railway service the motorbus has a probable future field of considerable proportions.

The electric-railway trackage in the United States is about 47,000 miles. Probably as much as one-half this trackage is not earning its operating expenses, including an adequate allowance for replacements and a fair return on the value of the property. The motorbus is certain to displace a large part of such electric-railway service, at least when replacements become necessary. We can look confidently to substantial improvements in the design of motorbuses that will increase their passenger-carrying efficiency. The greater such improvements are, the greater will be the amount of trackage displaced.

It is often stated as a maxim that the motorbus never can displace the electric railway for mass transportation. This, of course, depends upon the relative improvement in efficiency of the motorbus and the electric car. So far as space in the street is concerned, it is conceivable that a motorbus could be built of the same carrying capacity as a car, and such a motorbus certainly would not require more space in the street in proportion to its carrying capacity for maneuvering or for receiving and discharging passengers.

The total operating expenses of the average motorbus is not far different from that of the average electric car, either under city or interurban conditions. The railway is at an immense disadvantage, however, with respect to the necessary return on the investment, especially at present prices. On an average interurban electric railway, an 8-per cent return on the present-day cost of construction would amount to about 20 cents per car-mile for a line operated on 30-min. headway. On 15-min. headway, the corresponding return would be about

11 cents per car-mile, and on 12-min. headway, which is practically the minimum for singe-track lines, 9 cents would be required. For a single-deck motorbus an 8-per cent return would not exceed 3 cents per bus-mile. On city lines, with double track, an 8-per cent return on 10-min. headway would amount to 25 cents per car-mile, and at 5-min. headway, 14 cents; whereas a double-deck motorbus would require less than 4 cents per bus-mile. It must be borne in mind that the average carrying-capacity of electric cars is substantially more than that of motorbuses. This will not ordinarily affect the number of vehicles required during non-rush hours, but in the rush hours in some cases, twice as many motorbuses as cars might be required. Such rush-hour periods do not extend over more than one-third the operating day so that one-sixth more bus-miles would be required than car-miles to handle the same traffic.

Steam railroads have been experimenting with motorbuses adapted to operate on tracks, and this development has gone so far that about 100 such vehicles are in use or on order.

Breadth of the Field

The view that has been taken of the field of the motorbus from the standpoint of its relation to railways brings out in strong relief the fact that the breadth of the field depends to a very great extent upon improvements in the efficiency of the motorbus. In each division of the field a gain in efficiency should enlarge the opportunities of the motorbus in a geometrical ratio. The motorbus and the automobile engine are comparatively new and, unless history belies, we may look with certainty for radical improvements in their efficiency.

The steam railroad, which first became practicable about 100 years ago, spread rapidly in the first 20 years of its existence, but its usefulness was multiplied tenfold by three great inventions that came within the following 20 years, namely, the magnetic telegraph, the Bessemer-steel rail and the airbrake. But great strides in developing the usefulness of the railroads have come within the present generation, not as the result of revolutionary inventions, but by perfecting and enlarging upon the elementary principles of the railroad. Since 1900 the average drawbar pull of locomotives on American railroads has doubled and the average train-load has increased in still greater proportion. Fuel economy has been improving at the rate of about 1 per cent per year.

Electric railways likewise have made great advances in efficiency since their introduction about 30 years ago. In the first 10 years improvements in equipment were rapid and radical. In the last 20 years the efficiency of electric-railway operation has probably doubled, but little note has been made of it, because no spectacular improvements have been made and because the gain in efficiency has been more than offset by increases in wages and in the prices paid for supplies. In the important department of power production, the electric railways, beginning with small direct-current belted generators have, within 30 years, gone to large direct-connected units, then to alternating current with high-tension transmission and lastly to the steam-turbine drive. In place of the small hand-served fire-tube boiler, we find great boiler units of 10 times the early capacities, carrying three times the steam pressure and with manual labor practically eliminated between the coal car and the ash car. Waterpower has superseded steam to a large extent and a great economic use for it has been developed in conjunction with steam auxiliary service. A universal movement to combine railway power-load with commercial power and lighting load has taken place, thus obtaining a substantial saving through a diversity of demand.

The efforts of the motorbus industry must be directed toward producing a comfortable attractive-appearing vehicle with a maximum carrying-capacity approaching that of a modern street-car, sturdy and durable enough to keep maintenance costs within bounds and economical of operation. The industry must strive to give reliable service with as much care to the good-will of passengers as is exercised toward its customers by a well managed mercantile establishment. The farther the industry goes in these efforts, the more will the field of the motorbus be enlarged and maintained.

It is possible that because of the progress in engineering training and organization in the last quarter century, and because of the great commercial impetus of the present day, the development of the efficiency of motorbuses has proceeded at a more rapid rate than that of steam and electric railways did in their earlier days. Great improvements have been made in the efficiency of automotive vehicles in the last 10 years and it is entirely possible that future progress will assume a slower rate. It has been said that history is "bunk," but if one entertains respect for history, he would be rash to state that motorbus design has even approached its ultimate limit, or considering the few short years of its history to date, that its efficiency will not be developed at a greater rate than that of the railways. The railways, it is true, are under the spur of making both ends meet, but they are hampered by the lack of money with which to make improvements, and their financial condition is bound to have an effect in reducing the average quality of the engineering and the managerial talent attracted to them. On the other hand, the motorbus industry is an offshoot of a powerful and prosperous industry that developed within the last 10 years by leaps and bounds and is now second in rank in the United States. The insistent demand for the motorbus has resulted in much hurried and makeshift design. This will be corrected when more time and study can be given to it and when more experience in operation is available.

Apparently, the greatest opportunities for improvement are in body design. Bodies must be developed with much greater carrying-capacity, and a vast amount of intensive study must be given to structural details to produce low maintenance costs and attractiveness from the passengers' point of view, with the object of merchandising the service. The brains now enlisted in the automotive industry and the tremendous reward that is awaiting money-saving or money-making devices in this industry make it certain that great and possibly revolutionary improvements will still be made in the chassis as well as in the bodies. Many believe that the motorbus is in its infancy in this Country.

The Future of the Motorbus

In looking into the future development of the motorbus industry, it should be remembered that a tendency always exists for such movements to go too fast and too far. This brings disaster in many cases and inevitably casts a degree of disrepute on a whole industry.

In the case of electric railways, there seemed no limit to the possibilities. Urban systems extended their lines in very direction almost without regard to the length of haul for the unit fare or to the density of the population. Interurban lines were seriously talked of and were actually built in some cases for a population of less than 200 per mile. Great expectations were held out for

high-speed lines between large centers of population. This enthusiasm resulted in the construction of much trackage that never should have been built and had much to do with the depression in the electric-railway industry as a whole that resulted from drastic regulation, rising prices and the war. This was only a repetition of the steam-railroad exploitation in England in the 1840's and in the United States in the 70's. There are always investors who will rush into promising enterprises without a careful economic investigation and without trying to look into the future.

The motorbus is not open to so much danger with respect to overexploitation, because it does not require a large fixed investment and because it is so flexible of operation. It can be very seriously damaged, however, in the eyes of the public and of investors, if it even should get the reputation of poor service and financial failure.

The development and spread of motorbus business is vitally dependent upon an enlightened policy of governmental regulation. There can be no dispute that good service should be exacted and that wild-cat competition should be suppressed. The greatest danger of limitation of the motorbus field lies in the regulation of fares. If fares are artificially held down the service that can be given will be curtailed in quality and in extent. If the possibility of a liberal reward is permitted, then the motorbus will reach out farther in its zone of usefulness.

At the same time, motorbus operators must take care not to reduce fares or, what is the same thing, extend fare zones to such a point that their future profits will be compromised. In the early flush of prosperity, electric railways extended their lines almost without limit, while fare reductions and free transfers were being imposed on them; thus, as costs were slowly rising, the net income per passenger was diminishing. This tendency was offset by large annual increases in traffic in a period when the riding habit was being developed. Finally a time came when this offset of increased traffic failed and the electric railway industry came into straitened circumstances even before it was beset by jitneys and by the conditions produced by the war. Although increases in rates of fare were obtained, amounting on the average to over 40 per cent, such increases were hardly enough to offset the increases in operating cost. At the same time increases in fare have had a tendency to cut down the riding habit. It is doubtful whether it would be possible to fix electric-railway fares high enough to pay an 8-per cent return on the present value of the property used in their operation, because such rates of fare would drive away traffic.

With the enormous output of automobiles in this Country it may be thought that street traffic congestion ultimately will curb the number of motorbuses allowed upon the highways. The ultimate effect, however, should be the exact reverse. The private automobile makes very wasteful use of the street, in that on an average, as observed from a number of counts, it carries less than two persons. When streets become congested, the first action, after good traffic regulation, will be to look about for means of increasing the street capacity. It is reasonable, therefore, that the bus, which carries from 10 to 30 times as many persons as the automobile, will be encouraged rather than restricted. As streets become more congested, automobile owners undoubtedly will use good motorbus service in preference to their own cars. The great increase in the number of automobiles will certainly result in extending the program of construction of good roads. This in turn will help the motorbus.

In summary, there is a wide and inviting field for the motorbus; the extent of this field depends upon the efficiency of the vehicle and of its operation; the future depends upon the proper organization of the industry, the rate of improvement in efficiency as compared with improvements in railway efficiency and upon a wise governmental policy with respect to regulation.

JAPAN

THE credit of Japan is exceptional. The finances of the Empire have been handled with wonderful discretion. The World War left the Empire richer rather than poorer. Wealth was added in forms permitting increased industry and production. Money was not wasted or spent. The wealth of Japan is estimated by one authority at $23,500,000,000. A later authority gives the national wealth of Japan at $43,000,000,000. Obviously, in any case, the absorption of an economic loss of $1,000,000,000 or less will not take an indomitable people long. Great as the loss of life is supposed to be, it is infinitesimal when compared with the total population of the Empire, nearly 60,000,000 in Japan proper, 18,000,000 in Korea, 4,000,000 in Formosa, a total of nearly 80,000,000 people, who are among the most industrious and productive of any in the world.

Insurance in Japan is of comparatively recent origin. There was no native insurance of any kind at the time of the last great earthquake in Tokyo, Nov. 11, 1855, when about 50,000 houses were destroyed, with 6700 lives. The Japanese have a record of earthquakes dating 700 years before America was discovered. On the average for 21 years ended, 1905, Japan proper had 1461 earthquakes per annum, most of them slight. For a period of 1489 years, ending in 1905, Japan had 244 earthquakes more or less disastrous in character, or at the rate of one in approximately every 6½ years.

The Japanese have absorbed the principles of insurance and have followed them as effectively and wisely as they have learned and used the laws of science. They from the first readily saw that their insurance companies could not get an average, so-called, on earthquakes business, because their principal market would be in one country only, Japan, and that no obtainable rates of premium would pay the current losses and provide a surplus for the frequent disasters which their long history had taught them would be inevitable. Accordingly, insurance against earthquakes was never begun by Japanese companies and no premiums were taken. As a class earthquake insurance did not exist. The great British and other foreign companies never insured against earthquakes in Japan. To have done so would have been to indulge in a wild gamble and to have set aside the first principles of insurance. In fact the Japanese companies must long ago have been wiped out and been useless and unable to stand as a rock of strength to sustain the enormous fire risks of Japan and to act as a bulwark of credit. Japan will remain for generations a great field for fire insurance on account of the inflammable character of the materials of which the large majority of the buildings are composed, just as the United States will continue to be for practically the same reason.—H. P. Moore of American Foreign Insurance Association in *Economic World*.

The Theory and Advantages of Balanced Brake-Forces

By GEORGE L. SMITH[1]

ANNUAL MEETING PAPER *Illustrated with* DRAWINGS

DESCRIBING first the two methods of brake application in use in the United States, the theory of balanced brake-forces is then propounded by the author, who compares the methods and comments upon them. Illustrations are presented and used to analyze the brake forces, and practical applications of an equalizing mechanism used in road tests of an automobile are stated and considered in some detail.

Tests on wet pavements were made and skidding was studied, the skid-checking effects being noted and explained. Additional tests were made on hills, and the results of these are included, together with a presentation of the effects of speed and pressure. Wear on the tires and on the brake-lining, the effect on steering ability, the advantages of an automatic signal that brake-adjustment is needed and the measurement of individual brake-force are the other subjects discussed.

TWO methods of brake application on the automobiles built in this Country are apparent. One includes a pressure-equalizer to distribute the force exerted on the foot-pedal equally between the two wheel-brakes, while the other method dispenses with the equalizer and provides for the proper adjustment of the brakes by separate brake-adjusting means.

In the first method brake-band adjustment consists in providing sufficient clearance of the band to prevent dragging, and in regulating this clearance on each side so that very little throw of the pressure-equalizer from its mid-position will take place. With this adjustment made, it may be found that, upon testing the brakes, one wheel will lock before the other. This condition cannot be remedied by tightening the band on the wheel that does not lock, as the equalizer would in such a case still operate to equalize the pressure, and the formula $F = Pf$ would still govern; F representing the brake force, P the total pressure and f the coefficient of friction. With P equal on each side of the car, it is evident that F varies with f.

In the second method, where no pressure-equalizer is provided, it is possible to vary the brake pressure so that an equal braking-force will be obtained, the pressure on the side where f is greater being sufficiently reduced below the pressure of the other side to neutralize the variation in the coefficient of friction and for equalization

$$P_r f_r = P_l f_l \text{ or } P_r/P_l = f_l f_r$$

where r and l indicate right and left. This shows that the pressure must vary inversely as the coefficient of friction if equal braking-force is to be obtained.

COMPARISON OF THE TWO METHODS

Both methods possess good and bad features. Each eliminates some of the bad features of the other, but both are imperfect. For instance, the use of a pressure-equalizer overcomes the bad effects of the expansion of the brake-drum due to heat. Any increase in the circumference of the drum produces no effect on the pressure but merely draws back the foot-pedal a small amount, if external brakes are used, or allows it to travel farther down if internal brakes are used. In the case of external brakes, if the pressure-equalizer is not provided, the expansion of a drum due to heat causes an increase of pressure; this increase in turn produces more heat and consequent expansion until it may result in one brake doing practically all the work. On the other hand, with a pressure-equalizer used, any marked difference in f cannot be eliminated. If f is twice as high in value on one side as it is on the other, then the brake force will vary to the same extent.

To obtain an equal braking-force at all times, separate adjustment of brakes may appear at first sight to be the more desirable method, as frequent tests of the brakes and the proper adjustment of the bands would give uniform performance provided the variation in f could be followed-up with a fair degree of accuracy. Herein lies the trouble, however, as tests have shown conclusively that f varies so rapidly under certain adverse conditions that it is impossible to follow it up. With this fact recognized it must be admitted that, of the two methods described, the pressure-equalizer controls one variable in the equation, namely P, at all times, while the other method does not continuously control either f or P.

Manifestly, an equalization of the braking-force F is the desired result. It is mechanically possible to balance forces as well as pressures. Two forces equal and opposite in direction produce no movement, but when one force is increased over the other, movement must take

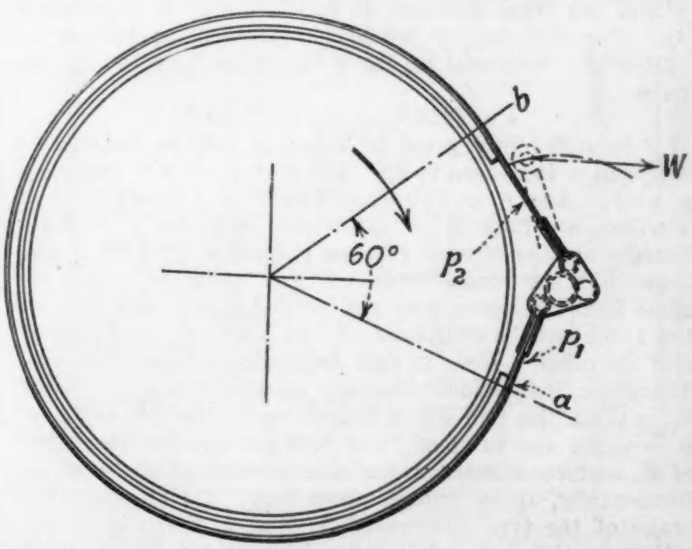

FIG. 1—A TYPE OF BRAKE IN WHICH THE ROTARY FORCE OF THE BRAKE IS RESISTED BY THE SAME MECHANISM THAT PRODUCES THE BRAKING PRESSURE

With the Drum Rotating and the Brake Applied, the Unit Pressure Will Be Greatest at the Point *a* and Will Drop to a Lesser Value at *b* and the Same Will Be True of the Tension on the Band

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place. If this movement is used to produce a variation in P in the direction to reduce the value of the larger F and increase the value of the smaller F, the result will be complete equalization of F regardless of the value of f or any change therein.

The usual method of securing the band against rotation is by the use of a brake anchor fastened rigidly to a non-rotating part of the axle, this anchor resisting the action of the force F, and the usual method of obtaining the desired brake-pressure is by the use of a toggle or a cam. While it is never safe to make the positive statement that a thing cannot be done, it appears from the following illustration that equalization of the brake force F cannot be attained by any mechanical device included in the brake-applying device.

Analysis of Brake Forces

Fig. 1 shows a brake of the type in which the rotary force of the brake is resisted by the same mechanism that produces the braking pressure. If it is assumed that the force W exerted by the operator is constant for this example, then the pull on the ends of the band will be governed by W and the sum $p_1 + p_2 = KW$, where K is a constant depending upon the leverages employed, and this must be true whether the drum is at rest or in rotation. In the former case, $p_1 = p_2$. In the latter case, p_1 is increased by the action of friction and

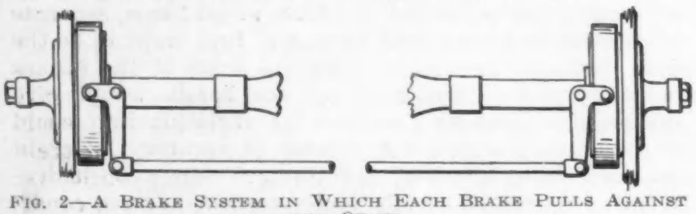


Fig. 2—A Brake System in Which Each Brake Pulls Against the Other

In This Design the Brake Exerting the Greatest Pull Will Rotate with the Drum and Will Cause the Other To Rotate in the Opposite Direction

p_2 is correspondingly reduced so that $p_1 - p_2 = F$, the brake force. With the drum rotating and the brake applied, the unit pressure will be greatest at the point a and will drop to a lesser value at the point b, due to the wrapping action of the band. Likewise, the tension on the band is greatest at a and drops to a lesser value at b, but the mean value of this tension will be $\frac{1}{2}(p_1 + p_2)$ or p and the total pressure P for 360 deg. is manifestly $4p$. For 300 deg. it would be $(20/6)p$, so that $F = (20/6)pf$. Substituting for p the value $\frac{1}{2}(p_1 + p_2)$, we have

$$F = [(10/6)\ p_1 + (10/6)\ p_2]\ f$$

If f is sufficiently great in value, p_2 will be reduced to zero and p_1 increased to $2p$. But $p_1 + p_2 = KW$ and $p_1 - p_2 = F$. Also $F = (10/6)p_1f$ and $F = p_1$ when $p_2 = 0$. Further, we have $p_1 = (10/6)p_1f$ therefore $f = 6/10$. Since f seldom if ever reaches the value of 6/10 it follows that the brake force for any value of f will be some figure between zero and p; and that the pull p_1 on the band will be composed of two factors, one being F and the other a force p_2 that develops the band pressure. Therefore, it is evident that any equalization of the force W, setting the two wheel-brakes, equalizes the value of $p_1 + p_2$ for any value of f but does not equalize the value of F that constitutes a variable portion of the pull p_1. Incidentally, these figures show why, in the case of a brake of the type illustrated in Fig. 1, there is no reaction on the foot-pedal, since f never can be expected to exceed the value of 0.60 and thus increase the tension p_1 beyond that exerted by the force W.

In a brake anchored at some intermediate point between the ends thereof, with the brake-setting mechanism producing no appreciable resistance to rotation, it is evident that the anchor will resist the entire force F of the brake. If this anchoring means is constructed so that each brake pulls against the other, by a system of bell-cranks and a connecting-rod as shown in Fig. 2, then the brake exerting the greatest pull will rotate with the drum and cause the other to rotate in the opposite direction. This rotary movement can be made to vary the brake pressure as seen from a study of Fig. 3. The compensating link l swings up or down, as the case may be, carrying the pivot a along the arc b; but, to produce no variation in the band pressure, the pivot a would have to travel on the arc c struck from the center o. Consequently, forward rotation of the band swings the pivot a down and in, thus easing-up on the toggle lever and slackening the band pressure. Backward rotation, on the other hand, will swing the pivot a up and out and tighten the band pressure.

The direction of the thrust of the compensating link will also produce a slight rotary force on the band which increases the resistance exerted by the anchoring means and, since this thrust will not be the same on each side unless the coefficient of friction on each side is the same, there will be theoretically incomplete equalization of the two brake-forces. This factor is a small one, however, since the distance d in Fig. 3 does not need to be excessive and, in actual service, has been reduced as low as $2\frac{1}{2}$ in. without interfering with the equalizing action. Also, the upward swing of the link to effect greater pressure swings it closer to the center o, thus reducing the leverage, while a downward swing to reduce the pressure increases the levrage. Thus, the moment of the unbalanced action due to the thrust of the compensating links can be held within small limits. It is not difficult to eliminate this variable, practically, by locating the compensating link and its centers so that the moment about the axle center is approximately a constant. Extensive tests have also shown that the coefficient of friction tends to equalize itself between the two sides, except for temporary variations due to moisture, oil and the like, and this would be expected since the work done by each brake, and consequently the heating and the wearing action, remain practically the same. Likewise, the action of the separator springs bearing on either side of the brake support also detracts slightly from theoretically perfect equalization but, in practice, this factor is also negligible, being such a small percentage of the total forces in action.

By reference to Fig. 3, it will be noted that the compensating links must pass above the axle center to obtain an equalizing action for retarding forward movement of the car. With a reverse rotation of the drum as in backing, the action of these links will be reversed; the brake pulling the hardest will rotate backward with the drum and the pressure will be increased, while the brake on the other side will rotate forward against the direction of rotation of its drum and the pressure will be released. So, the result is complete unequalization of forces. Hence it is necessary to employ the backing latches t shown in Fog. 4. The drawing at the left shows the latch engaged, which is its normal position with the brakes off, or with the brakes applied in backing, in which latter case the latch and not the equalizer rod resists the force of the brakes. In the drawing at the right the latch is shown disengaged by the tension on the equalizer rod, the latter being raised bodily until all four pivots, latch to bell-cranks and latch to rod, are in the same line. It is thus evident that the latches perform two functions,

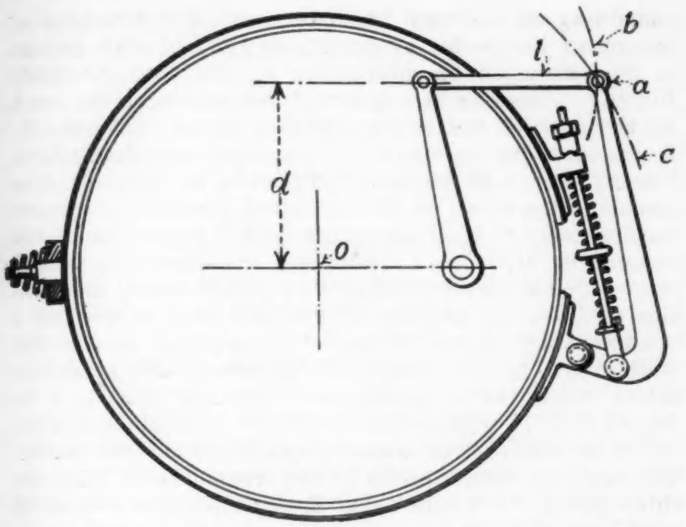


FIG. 3—HOW THE ROTARY MOVEMENT OF THE BRAKE-BAND CAN BE MADE TO VARY THE BRAKE PRESSURE

The Up-and-Down Movement of the Compensating Link *l* Causes the Pivot *a* To Move along the Arc *b*, but to Maintain the Brake Pressure Constant the Pivot Would Have To Travel on the Arc *c* Having Its Center at *o*. Consequently Forward Rotation of the Band Swings the Pivot *a* Down and In, Thus Easing Up on the Toggle Lever and Releasing the Pressure on the Brake-Band. Rotation in the Opposite Direction Tends To Swing the Pivot Up and Increase the Pressure on the Brake-Band

that of centering the equalizing mechanism when the brakes are off, and of rendering it inoperative when retarding a rearward movement of the car.

The utility of an equalizing mechanism of the above type depends principally upon the degree of reliability of the frictional characteristics of the brake-lining. With f a constant, its usefulness drops to zero. Investigation of this subject developed the fact, however, that f is a decided variable, sometimes as low as 0.13 and sometimes as high as 0.52, and that its rate of change is also exceedingly variable. The same increase or decrease may take place in several days or in a few minutes, depending upon conditions. From this it would seem that equalization of the brake force is necessary, and experiments with mechanism of this type confirm this opinion, as will be seen from the following text.

Practical Application

The first car equipped was a roadster; it weighed 2800 lb., had a 119-in. wheelbase and 34 x 4-in. tires. In addition to the equalizing mechanism, a simple device for noting the movement of the equalizer rod is described as follows: About 25 turns of resistance wire were wound around the equalizer rod for a distance almost equal to the full throw of the rod from one side to the other, as fixed by limit stops provided for the purpose of preventing too great an angular movement of the bell-cranks. This wire was insulated from the rod and connected to the dash-light circuit. A finger secured to the rear axle bore on the central portion of the coil of resistance wire and formed a ground for the light circuit. Connections were such that any movement of the equalizer rod to the right would cause the dash light to burn brightly and then go out, as the finger left the resistance coil just before the rod reached its full throw to the right; conversely, the light would burn dim and then go out just before full left-throw was reached.

The first experiments comprised tests to determine the limits of the mechanism. The brakes were thrown out of adjustment by slackening one band until the throw of the equalizer rod in producing a balance of work was such that the bell-cranks hit the limit stops on one side. From this position of adjustment, the slack band was tightened and the tight band slackened until the equalizer rod would throw to its limit of movement in the other direction. This was done many times and in both directions of movement. The results showed that six turns of the adjusting nuts were required to produce full throw between the limit stops. With the threads used, this meant a linear distance of 0.24 in. on a circumference of 14-in. diameter. It was estimated that this range of movement was sufficient to compensate for any possible variations in the coefficient of friction, and subsequent experience has demonstrated this to be a fact.

Tests on Wet Pavements

In testing the device on wet asphalt streets, a very large number of runs have been made at various speeds of from 10 to 35 m.p.h. and, in nearly every case, the car has run straight ahead even with the hands off the steering-wheel. In some instances, at speeds as high as 35 m.p.h., this has been the case even with one wheel locked and the other rolling, the locked wheel having a tire that was well worn while the other wheel was equipped with a new one. In no case has the car ever slewed more than 10 deg. one way or the other, except when intentionally skidded by movement of the steering-wheel or on snow, ice or a very greasy pavement.

The explanation why a locked wheel did not produce a skid was discovered after several months while adjusting the brakes of a Yellow Cab in Chicago. In stopping the cab, it was noted that the equalizer rod threw a little to the left, then the left wheel locked and the rod immediately moved back to the right a short distance. In this case, the movement of the rod to the left showed that the left brake was inclined to pull the harder and that the right band should be tightened. When the left wheel stopped rolling, however, the friction action of the brake on the drum ceased and the pull to the left on the equalizer rod then resulted from the torque produced by the sliding friction of the wheel on the road. Since the rod moved back a little as soon as the wheel locked, this would indicate that the rolling friction of a tire on the road is greater than the sliding friction, a well-known fact and productive of skidding, but seldom demonstrated mechanically. The reverse

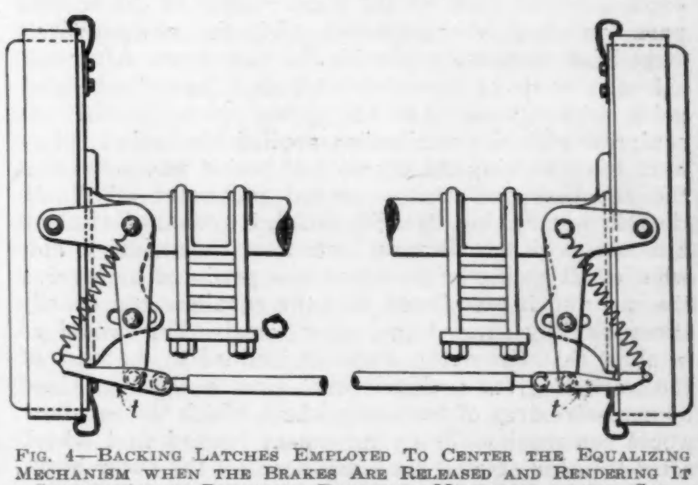


FIG. 4—BACKING LATCHES EMPLOYED TO CENTER THE EQUALIZING MECHANISM WHEN THE BRAKES ARE RELEASED AND RENDERING IT INOPERATIVE IN RETARDING BACKWARD MOVEMENT OF THE CAR

The Drawing at the Left Shows the Latch Engaged, Which Is Its Normal Position with the Brakes Off or the Brakes Applied in Backing, in Which Latter Case the Latch Resists the Force of the Brakes. In the Drawing at the Right the Tension on the Equalizer Rod Has Disengaged the Latch, the Former Having Been Raised Bodily Until All Four Pivots, the Latch to the Bell-Crank and the Latch to the Equalizer Rod, Are in the Same Straight Line

movement of the rod also did another thing that illustrates why a skid does not start as soon as the wheel locks. It slackened the band pressure on the opposite brake, as it permitted a slight rotation of the band with the drum and thus decreased the power of the right brake to correspond with the drop in power resulting from the locked wheel. Of course, the driver could counteract this action by a greater pressure on the foot-pedal, but he would not be apt to to this and could not do it to the extent of immediately following-up the movement of the equalizer rod. In this connection, experiences with tires have demonstrated the fact that more or less variation in the holding power of the wheels, which has in the past been attributed to a variation in the braking action, shows-up as being due to the tires when the brake force is balanced. Two high-grade tires of the same make and same age should be put on the rear wheels at the same time if the best results are to be obtained with any type of brake.

Skidding and Skid-Checking Effects

While practically all tests on wet pavements showed no tendency to skid, four cases are recalled where a slight zig-zag movement was noted. In the first instance, the brakes were applied at a speed of about 25 m.p.h., the front wheels being held perfectly straight. The car slewed about 6 or 8 deg. to the right, checked itself and then slewed a lesser amount to the left and again checked itself.

At a speed of about 55 m.p.h., the brakes were applied on a wet brick-pavement and a very slight and easy slewing action to one side and the other was noted. This was an unintentional test, as the situation required such action to avoid a collision. In turning in a narrow street on a wet day, the driver once fooled himself in trying to skid the car around to avoid backing, at the same time not having the equalizer in mind. The car slewed about 10 or 15 deg. and then checked itself. This test was very complimentary to the equalizer but not so creditable to the driver's presence of mind.

This checking action was never anticipated and, for some time, the reasons therefor could not be explained. It was thought that the zig-zag movement was produced by what might be termed a hunting action of the equalizer, although this did not seem to be a satisfactory explanation in view of the light weight of the moving parts involved as contrasted with the comparatively large braking forces producing the movement. After considerable study of the question from a theoretical standpoint, it happened that the driver of a Cadillac car equipped with the mechanism applied his brakes rather hard when turning the car around, and it was noted that the equalizer rod threw toward the outer wheel, although, when going straight ahead, it remained at about a central position. Several tests were then made to note what effect on the brake action was produced by turning the car, and it was found that the equalizer rod usually threw slightly toward the outer wheel. This would go to show that the outer wheel is inclined to do most of the work if given a chance and, since a skid is caused by excessive drag of the inner wheel, which the equalizer would compensate for by movement toward that wheel, after the skid started the work done by the outer brake would be increased by the rotary movement of the car, thus assisting the equalizer in balancing the brake action and probably overdoing it.

This explanation is offered as a probable one only and may be far from the actual truth. The amount of side drag of the wheels on the road undoubtedly has something to do with the case, also the direction of motion of the center of gravity of the car with respect to the direction of application of the two retarding forces produced by the action of the wheels on the road. In the case of the slewing motion noted at 55 m.p.h., it appeared to be more of a gentle pendulum-action. The movement of the center of gravity of the car corresponds to the direction of the pull of gravity and the retarding force of the brakes corresponds to the pull of the suspending wire of a pendulum; consequently, temporary variable forces produced by air-currents, inequalities of the road and the like might tend to develop a pendulum action even though the torque of each brake were absolutely the same. At high speeds, this pendulum action might be expected; but, for low speeds, it is doubtful if it would ever develop. Accurate measurements of the force of deceleration, the period of oscillation and the speed might throw considerable light on this subject. It is hoped that these data may be obtained in the near future.

Additional Tests

In January, 1922, the car was coasted down Conowingo Hill with the clutch out, snow packed hard and chains on. This hill is about as dangerous as any in the Allegheny Mountains although not so long. The car controlled perfectly with the brakes on and was alternately slowed-down and speeded-up between speeds of 10 to 25 m.p.h. Later in the year, this test was repeated in good weather to note the heating effect. At the bottom of the hill, after coasting a little more than 1 mile, both brakes were heated alike and were not so hot as to blister the paint except on the brake bands.

In May, 1923, on a trip from the City of Washington to Cleveland, a very interesting illustration of the action of the equalizer was given in coasting down the west side of Cove Mountain, near McConnellsburg, Pa. It was rainy and the road was wet. At the beginning of the descent the clutch was thrown out, the gear was left in high and the brakes were used to control the car. It was noted at the start of the coast that the brakes were not holding as well as usual, since considerable foot-pressure was required. Soon the equalizer began to throw to the right, showing a pick-up in f on the right side. This movement to the right increased until the dash light burned nearly at full power, but not enough to break the circuit. Then it began to decrease, showing a pick-up in f on the left side, which increased until the equalizer moved over to the left of the neutral position. Finally, the brakes began to smoke considerably and were released; at that time, the equalizer rod was throwing to the left of the neutral position about one-half of its full throw and both brakes were holding so well that a very light foot-pressure would lock the wheels.

The duration of this test was probably not more than 5 min., during which time the coefficient of friction increased most decidedly on both brakes but not in a uniform manner, as the right side increased considerably before the left side began to pick-up, although the left side finally increased more than the right. This would tend to explain many skidding accidents that happen even to drivers who are careful about keeping their brakes in efficient condition, and goes to show that frequent brake adjustment is not necessarily much of a safeguard. These variations in f have been noted on every long trip where observations were made by the use of the dash light. In fine weather they are not excessive, as shown by very little movement of the

equalizer rod, but wet weather, slush, snow, mud and the like produce decided changes for short periods of time, although usually not of so great an amount as to require any change in brake adjustment. In fact, records have been made of 3 months' running with a taxicab without any adjustment of the brakes whatever, and a record of 6 months' running was made with a Cadillac car.

Effects of Speed and Pressure

It has been noted on several occasions that speed and pressure have an appreciable effect on the action of the mechanism. As previously cited, the action of the equalizer rod in turning would go to show an increase in f on the outer wheel caused by its increased speed of rotation. Also, in observing the movement of the rod as the speed dropped, it has been noted frequently that just before the movement of the car is arrested an appreciable movement of the equalizer rod will take place. This seemed to take place mostly with one particular make of brake-lining. Of course, a considerable change in f for a change in speed may take place without showing-up in a movement of the rod, such as an equal increase or decrease on each side when f is the same on each side, or an increase or decrease maintaining the same proportion between the two sides when f is not the same. On several occasions it has been found possible to cause this rod to shift its position by increasing the pressure. This movement for an increase in pressure was first discovered accidentally. After passing through a stream at a ford, it was noted that a clicking noise could be made by braking hard but was not produced by a moderate pressure. Upon investigation it was found that the bell-cranks were hitting the limit stops on one side, and this caused the click.

Wear on Tires and Brake-Lining

Two sets of Royal cord tires have been used on the rear wheels of this test car, each set being used until the tread was worn smooth. When the tires were removed, the wear on each side was so nearly the same that it was impossible to tell which tire was worn down the most. The rear wheels do not lock easily, as it is seldom that one locks without the other locking also; consequently, very little rubber is dragged off the tires in this way. As would be expected, much more uniform and effective brake action was noted soon after the equalizer was applied and, on long trips, less variation in the power of the brakes was noted.

The brake-lining wear appears to be more uniform and the tendency to wear down at the ends appears to be entirely eliminated, the maximum wear taking place along the upper and rear portion about 15 to 30 deg. to the left of the top. Accurate data relative to mileage have not been taken except in the case of a taxicab in the City of Washington. This cab ran 20,080 miles while using one set of brake-linings. It is estimated that the test car already mentioned ran about 26,000 miles with one set.

Effect on Steering

Although front-wheel designs have been laid out on the drafting board, test sets have not yet been constructed; therefore, it is impossible to give any record of tests. However, it has been found that it is not only possible to obtain practically perfect equalization, but also to relieve the steering-gear of all strains due to the brakes. This is evident when it is seen that the two brakes pull against each other. Only when the equalizer rod bears against a limit stop would any turning action be imparted to the wheels. This would mean that one brake or the other needed tightening, and an audible warning sound produced by the equalizer mechanism under such a condition makes it impossible for the driver to proceed in ignorance of the fact that his brakes need attention. In turning the wheels, the bell-cranks swing with the wheels but through an angle that is approximately the mean of the two wheel-angles. In this manner the pull of the band is always practically at right angles to the short arm of the bell-crank which is, of necessity, pivoted on the king-pin. This method of hooking-up also permits the use of vertical king-pins with the usual offset of the wheel, as center-point steering is not necessary since there is no turning moment about the king-pins due to the brakes, neither is any compressive stress applied to the tie-rod. In fact, the steering-gear of the car carries no brake load whatever.

Brake-Adjustment Signal

In reference to the warning signal indicating that the brakes are out of adjustment, it is possible at practically no increase of cost or complication to arrange the mechanism so that the driver will not only be notified that adjustment is necessary, but also which one of the four brakes needs adjustment. This would seem to be a most important and desirable arrangement and would make it practically impossible for anyone to drive his car when the brakes were in a dangerous condition without knowing that such is the case.

In providing connections from the brake levers to the brake-pedal, it is evident that positive action must be obtained for each side, and any cross-shafts used must have sufficient torsional strength to resist the torsion produced by the action of the compensating links in varying the band pressure. One cross-shaft from right to left toggle-lever and running under the pinion housing with one pull-rod connected to a lever on this shaft near the left side of the pinion housing gives a simple and efficient installation. A pressure-equalizing mechanism must not be used, as it would counteract the action of the equalizing mechanism controlling the band rotation and prevent a variation of the band pressure to follow-up the variations in the coefficient of friction.

Measuring Individual Brake-Force

While no accurate measuring instruments have been devised to test the actual brake-force for each wheel, tests have been made by the Bureau of Standards with its decelerometer, using the roadster car already described; it showed a very uniform performance of the brakes under a variety of conditions. Although the data from these curves have not been worked-out, a comparison of them reveals the fact that tightening one brake and slackening the other a corresponding amount, or wetting one brake thoroughly, resulted in no appreciable variation in the curve, although each variation of the condition of test produced a movement of the equalizer mechanism to correspond. By comparing the ordinates of the curves taken with various changes in the brake-adjusting nuts up to a maximum of two plus-turns on one side and two minus-turns on the other, and with one or both brakes thoroughly wet, the maximum variation from the mean values of these ordinates was 9 per cent. Later tests of a six-cylinder car of 126-in. wheelbase showed a maximum deceleration of 15 ft. per sec. per sec. and a minimum of 13 ft. per sec. per sec. This is considered to be about the maximum that can be obtained from rear brakes.

The greatest merit in the mechanism described herein results from the mechanical principles brought into play, which render it impossible for variations in the value of the coefficient of friction to upset the uniform action of the two brakes in exerting the same retarding forces on each side; and, since the two brakes pull against each other, one cannot take hold before the other. Experience shows that it prolongs the life of both the lining and the tires and greatly reduces the necessity of brake adjustment. It stands to reason that it must be a desirable and necessary feature to any automobile braking system, since it performs the same function in retarding the speed of the car that the differential does in accelerating it.

OUR ECONOMIC REVOLUTION

A SYSTEM of popular and universal education, particularly if it is well directed toward practical questions, tends to move people up in the economic scale. By "up" I mean merely toward those occupations where men are relatively scarce; away from those occupations in which men are poorly paid and into those occupations where men are relatively well paid. Of course those things are identical in content. We were doing that so rapidly that we were tending all the time to make labor scarce in the poorer occupations and abundant in the higher occupations. Then there was a relative scarcity of men, compared with other countries that did not have such a policy as ours, in the poorly paid occupations.

Wages are high and are going higher. Do not imagine that wages will get any lower than they are now. The cost of living will not be any less than it is now; it will be worse. It will cost more. That is already upon us, and we are getting ourselves adjusted to it.

Ten cents a day set aside by every worker in a shoe factory will buy that factory in a very few years or another one like it. Of course when the workers were poorly paid it was hard to save 10 cents a day, but they are actually saving it now and more than that and perhaps having soda water besides or the movie tickets or Ford automobiles or something of that kind in addition to the saving and investing that they are doing. So, ownership of the factories and the plants by the workers themselves is coming more rapidly in this Country than it can possibly come in any other country, and it is coming without any reformer knowing that it is coming. He has not had anything to do with it. It is coming because the ordinary economic forces are putting into the hands of the workers the money with which to buy the plants in which they are working.

The workers will exercise more and more control over the business as much as they want. They will find if they try to run a great factory by the town meeting plan that it will not be very profitable to them. As soon as they discover that, they will want to leave the factory in the hands of the most expert manager they can find.

Suppose, through the increased savings of multitudes of people, helped perhaps by prohibition and a few other things, you look around and find there is no problem of capital; there is plenty of capital around and people with capital are finding difficulty in investing it. Then capital is approaching the stage of superfluity and the capitalist will not control as he did before. That will come automatically. And when it comes in that way, you will find it to your interest to deal with the laborer on that basis; and when he finds that such a policy is favorable to his interest, that is the way it will be done.

Educated women, cultured women, women with some means, must expect to do their own work more and more, because the wages of servant-girls will eat up more and more of the salary of the head of the house. We must rebuild our houses with that in view and plan our household economy with the expectation that there will be no servants for most of us.

The old New England kitchen, or something like it, will probably come back, as a necessity, when the work has to be done by the people of the household, and there is no servant that can be sent off, isolated from the household, to do the work alone. The people of the household enjoy work sometimes if they can enjoy the pleasure of having company at the same time.

The great point is that we are getting prosperity for all classes and approaching equality for all, while preserving another thing that we always prize, freedom to do what we agree to do rather than what we are commanded to do. We are making daily progress toward a solution where we shall have both those good things.

That is why the revolution we are having in this Country is much more fundamental than anything they have anywhere else in the world; it is the only revolution that amounts to anything. Suppose the Russians did succeed in making everybody prosperous, as they cannot, by the system of extreme authority; they would then have surrendered freedom to have prosperity.—T. N. Carver in *Harvard Alumni Bulletin*.

ENGINEERS AND THINKING

IF the engineer is not keenly interested in the cost of his project and in the financing of it, he not only lacks the urge to produce the most economical design but also sooner or later he will let his employer or client in for a radically bad piece of engineering. A good piece of engineering is the simplest and cheapest design that will give the required results. The product must be judged not only from the standard of performance but also that of economy. The estimates are not something to be exceeded, but "bogys" beyond which expenditures must not go.

Most of us have no conception of the poor repute of engineers with financiers. It is because of the uncertainty as to the number of dollars they actually will spend before the project is wholly completed.

Apparently it is perfectly possible to go through a whole course of instruction from kindergarten to post-graduate college course without being taught how to think. Mathematics, grammar, Latin and Greek are excellent exercises in thinking and reasoning, but one can, so to speak, lock up one's knowledge of each of them in a separate compartment of his mind and only apply to each the particular kind of reasoning required and never apply it at all in any other sphere of activity whatsoever.

The great military strategists like Alexander the Great, Cæsar and Napoleon were great engineers and inventors also. They were geniuses, but they left behind them certain simple principles, self-evident truths applicable not only to warfare but also to government, business and engineering. Later, the methodical Germans thought so much of these principles that they applied them not only to war but also to business and engineering with most conspicuous success. They evolved a method called the estimate of the situation. By this method the objective sought is first clearly defined; then the difficulties are studied and then the resources. The final plan can then be undertaken rationally.

In our everyday life we follow this sequence unconsciously; but, because it is unconscious, the objective, the difficulties and the resources are not defined as clearly as they should be.—Ralph Rainsford before Engineers' Society of Western Pennsylvania.

Engines for Motorboats

By George F. Crouch[1]

Motor Boat Meeting Paper

Harmony of effort toward the perfection of the product and a certain mutual understanding of the problems of engine and boat building and naval architecture is advocated. The viewpoint is that of a naval architect concerned with the installation of marine engines in the hull of a vessel and with giving an owner what he demands as to speed, reliability and accommodations. But the author finds that the problem today is that of working-out a 1924 engine-installation witih a 1904 engine-control arrangement.

Remote control of the spark, the throttle and the reverse-gear is discussed and suggestions for improvement are made. The architect's desire is to place the engine as low in the hull as possible, so as to reduce the angle of the propeller-shaft. Obstacles that hinder such accomplishment are mentioned and comments are made concerning flywheel enclosure. The author hopes for a reliable engine that will have an efficient and reliable reduction gear as an integral part of the engine. Minor details relating to reliable and compact installation are presented and suitable accessories are considered. The subject matter of the paper applies mainly to high powered cruisers and to boats of the runabout type.

To give an owner the best possible boat for his money, the engine boat builders and the naval architect must work in perfect harmony toward the perfection of the completed whole and each must understand the problems of the others to some extent. Hull style, arrangement and the general features of the accommodation of any boat are determined by the owner; the naval architect and the engine builder try to meet the owner's requirements, at the same time keeping abreast of engineering advances in their product. We are forced continually to remind ourselves that the owner does not care a straw about the more intricate technical features and superiorities, either of hull or of engine. What the owner wants is results, and he knows when he gets them. The marine-engine business and the boat business will grow in volume exactly as the value given the boat owner for his dollar increases. My purpose is not to offer advice to the builders of engines, but simply to show them the point of view of a naval architect who is concerned with the installation of their engines in the hull and with giving the owner what he demands in the way of speed, reliability and accommodations, in the hope that it may lead to better boats and, therefore, more boats.

Most boats built today demand some form of engine installation that requires more or less of the so-called "gas-pipe and hay-wire rigging" on the part of the boat builder. The engine builder is still giving us an engine that, so far as control of the spark, the throttle and the reverse-gear is concerned, is practically identical with the 1904 model. Twenty years ago, when the engine in a cruiser was placed either in an open cockpit or in the cabin, it was logical to mount the spark and the throttle at the engine and to have the reverse-gear lever extend directly up from the gear housing. Today the opposite is true. In cruisers, except in the larger sizes, the engine is placed under a bridge deck or in some other out-of-the-way location and is started and handled by the helmsman from his position at the steering-wheel. In the runabout class, there is no getting away from the demand for the centralization of all controls at the helmsman's position at the fore end of a fore cockpit. The public has been shown by the motor car that an engine can be placed in a small compartment and left unattended; therefore, the public demands the same capability for a boat engine. We are then confronted with the problem of working out a 1924 engine installation with a 1904 engine-control arrangement.

Distant Control

Spark and throttle controls for these installations, which are made-up by the boat builder, consist of a system of bell-cranks and rods that do the work after a fashion, but are apt to have much lost motion and are noisy and troublesome due to vibration at certain speeds. My own experience has shown that, even with these objections, the bell-crank-and-rod form of linkage is more satisfactory than Bowden wire. I have often wished that the engine builder had placed upon his engine some form of control to which the boat builder might connect a shaft of light tubing, operating the spark and the throttle by turning this shaft instead of the usual push-and-pull rods. This shaft would not vibrate if supported in simple bearings, and a small fabric universal-joint at the connection to the engine would prevent any jamming. The engine builder can reply that such a control scheme is readily worked out by the designer and the boat builder. This is true, but a cheaper and a better job will be done by the builder of the engine than by the hull builder.

Reverse-gear control from a distant point is more of a problem on account of the greater amount of force that must be transmitted to work the gear. When the engine is directly below the helmsman, as it is in many cruisers, the connection to the reverse-gear lever is made more readily than in a large runabout where the helmsman may be from 10 to 12 ft. ahead of the gear. In that case it is not so simple to work out a control that operates smoothly, has little spring or lost motion and, at the same time, is light and compact. I have wondered whether it is possible to take advantage of the work that has been done on the hydraulic control of motor-vehicle brakes and apply it to the development of hydraulic control of the reverse-gear. Some years ago, a crude form of control of this type was shown, but the demand for it was not acute on account of the hull arrangements in use at that time.

In the storage-battery used for starting and lighting, a source of power is available which can be utilized to actuate the reverse-gear by a small electric motor, suitably geared-down. With either of these suggestions worked out in a reliable way, a real, one-man control could be fitted easily to any boat, large or small, no matter how remote the helmsman may be from the engine. Even such a simple change as swinging the reverse-gear lever in a horizontal arc about a vertical shaft in place of using the conventional vertical arc around a horizontal shaft, would, in the majority of cases, greatly simplify the problem of connecting suitable controls.

[1] M.S.A.E.—Naval architect, New York City.

Engine Dimensions

With regard to the engine itself, I have little to say because the improvement in performance has been continuous and rapid since the close of the war. But it may be wise to remind the engine builder that the naval architect fights for inches and even quarter inches when working-out some of the more highly developed types of high-speed runabout. This is particularly true of the architect's desire to get the engine as low in the hull as it can be placed, so as to reduce the angle of the propeller-shaft. Any boss or projection that tends to increase the depth of the crankcase, and especially the depth of the crankcase under the reverse gear, must be avoided. No plugs, drains, screens, cocks or connections can be placed below the level of the top of the bed timbers, and the drop from the center of the shaft to the top of these timbers should be kept just as small as it is possible to do.

At the after end of the engine, it is difficult to get sufficient depth in the bed timbers and the engine builder should avoid carrying the supporting flanges of the engine too far aft. If he feels that the after end of the reverse-gear housing can be extended some distance aft of the last holding-down bolt, it will aid the naval architect in making a better installation of the engine, particularly in a light, small, high-speed hull.

Enclosing the flywheel, as it is now done on all the later marine models, has been a decided improvement that makes for safety and cleanliness, but a few of these enclosures are too wide to permit the bed timbers to pass forward without being cut down to such an extent that they are weakened greatly. This should be changed to permit the timbers to pass and, since too great a width between the timbers is a detriment to a good bed, a reduction in the enclosure diameter, where this is possible, is advocated rather than an increase in the spacing of the beds.

Reduction Gears

Now that the marine-engine builders can, and do, build engines of moderate size and weight that will run all day, day after day, at 1000 to 1200 r.p.m., with remarkable fuel and oil economy, I believe that all naval architects are looking forward to the time when it will be possible to procure an engine of that type fitted by the engine builder with a really efficient and reliable reduction gear that is an integral part of the engine, just as reverse-gears are built today. With a powerplant of this type, we shall be able to turn the propeller at the revolutions necessary to get real propeller efficiency and give to the owner a cruiser or a work-boat that, for economical operation, will be hard to beat.

We know that reduction gears have caused trouble for almost every one who has had the courage to experiment with them so far, but they have been somewhat makeshift in design and construction and have never been given the thought that is absolutely necessary to make them satisfactory. An engine of moderate power, turning the propeller at a speed of about 200 r.p.m., will drive a large heavy hull in a way to amaze those of us who think of no speeds below 800 r.p.m. at the lowest. The combination of high-speed engine with the reduction gear will have many advantages over the large heavy-duty engine of the same power, turning a propeller at the same speed. It will take up about one-half the space in the boat, will have about one-half the weight and should cost the builder about one-half as much to construct. Moreover, the propeller revolutions at full power can be made whatever the achitect feels is needed to give the highest propeller efficiency in any hull, by a simple change in the ratio of the teeth on the pinion and the gear.

Minor Details

Many minor details add to the ease with which the boat builder can make a reliable and compact installation of an engine. For instance, it is often difficult to work-in an easy exhaust lead when the after end of the exhaust-manifold points directly aft. More space than is needed by the engine must be given between the after end of the exhaust-manifold and the control bulkhead, so as to sweep the exhaust line down and out to the side and thus leave the space behind the bulkhead clear. The practice of fitting a cast elbow having a bend of about 45 deg. has much to commend it, particularly when it can be turned to any desired direction and contains the fitting for introducing the cooling water into the exhaust line.

Since the only possible place to gain entrance to the crankcase is from above the center line of the crankshaft, hand-holes are needed on marine engines. Without them, it becomes necessary to lift the entire engine out of the boat, or to remove the cylinders, to inspect or adjust bearings or even to clean out the crankcase. Hand-holes should be large enough to permit working inside the case and should be placed to clear the fittings such as the generator, the starter or the water-pump.

Now that many marine engines are using overhead valves, the architect finds that some of these models take up much more height than the older type. This is of no consequence in a Diesel engine or a heavy-duty machine, but in a small highly powered runabout or a speedy bridge-deck express-cruiser, it may be objectionable if combined with a long stroke. I have yet to see why the marine engine with overhead valves should be built with a long stroke. Neither the builder's guarantees of fuel consumption nor the engine weight and overall size seem to offer a reasonable solution. From the standpoint of compactness, an engine-stroke but little greater than the bore is much better than using a small bore and a long stroke.

Marine Accessories

With regard to the various accessories used on the marine engine, the builder must exercise the greatest care in selecting these parts. I have seen more trouble in the last several years with the accessories, such as the reverse-gear, the starter, and occasionally a pump, than with the engine itself. An owner places upon the builder of the engine the blame for the failure of any part connected with the engine to give complete satisfaction. Reverse-gears should be selected which have a real neutral position, particularly now that remote control is demanded. Bands must not drag when the gear is in the ahead position and must hold in reverse; clattering bands are sometimes found which make more noise than the engine itself. Starters must be chosen which have ample power to spin the engine, and they must not jam when the engine fires; oil-pumps and water-pumps should not require priming at every start.

I wish to emphasize that I have been speaking chiefly about engines that are intended for installation in hulls that carry high power for their size. In the slow, heavy cruiser or work-boat, many of the points I have mentioned are not of great importance because the margins of space and weight are much more liberal. I may appear to have stressed these minor points out of all rea-

sonable proportion to their importance, unless the requirements of the highly powered cruiser and the runabout are kept in mind.

On some engines, the features I have brought-up are well taken care of. But when I see, as I have seen lately, new models brought out that require connections to be made down on the side of the lower base, below the level of the top of the engine girders, others with bases far too deep at the after ends and with supporting flanges placed some distance below the center-line of the crankshaft, I believe that there is even yet some lack of understanding on the part of the marine-engine builder of what the boat builder and the boat owner require in marine-engine design.

PACIFIC COAST INDUSTRY

THE leading industries of the Pacific Coast in 1919, as shown by the Census of 1920, were, in order of value of product, shipbuilding, lumber and timber products, petroleum refining, canning and preserving of fruits and vegetables, flour milling, slaughtering and meat packing and dairy products, butter, cheese and condensed milk. These include all industries in the Census classification in which the Pacific States, together reached $100,000,000 or more in value of products. Shipbuilding on the Coast, as elsewhere in the United States, was vastly expanded in response to war demand. From 1910 to 1920 the Coast increased its production of vessels of all kinds more than fifty-fold. Almost one-fourth of the value of shipbuilding in 1919 is credited to that section.

The Pacific States furnished over one-fourth of the product of the lumber industry. In petroleum refining the rank of the Coast district was less notable in 1919 than at the present time; about 13 per cent of the American industry was carried on there. Canning of fruits and vegetables is the industry most highly localized on the Coast, as more than half of the value of such products was claimed by the three States. In flour milling, 9 per cent of the American product, and in slaughtering and meat packing more than 3 per cent were produced on the Coast. The value of butter, cheese and condensed milk from that section amounted to nearly one-tenth of the Country's production.

In spite of swift overland transportation and a reduction of 60 per cent in the time of intercoastal shipments through the construction of the Panama Canal, one-fourth to one-third of the inventories of jobbers and merchants is often in transit. The interest on capital thus tied up in goods to arrive represents an enormous loss. The local manufacturer, even if his goods produced in Los Angeles must be shipped more than 1000 miles to Seattle, can save his customer time and interest as compared with manufacturers in St. Louis, Chicago or New York City. Branches of national companies are being set up on the Coast, and in addition the distribution of outside products is being improved. Automobile assembling plants are congregating in Coast cities. Ample evidence is at hand of the fact that the Pacific Coast no longer depends to any burdensome degree on outside sources for its capital requirements.

To render any locality self-sufficing, steel manufacture is fundamentally necessary. The manufacture of steel in the quantities and the qualities essential for ordinary industrial purposes is dependent on large and accessible supplies of coking coal and ore fields not too far distant from them. There are no iron-ore beds within reach of the Washington coal-fields, but Coast interests are bending their efforts toward the production of pig iron in Utah, where coal and ore can be brought together. This iron is to supply steel mills in California. The growing demands of 11 States will furnish a market for a much larger volume of steel products than the new industry can supply. Recently plans have been matured for the establishment of a completely equipped blast-furnace and steel-plant in Southern California.

THE HOME MARKET

Probably the chief question for Coast manufacturers is how much of the trade of the United States they can secure. Here the long transcontinental mileage, that protects new industries on the Coast rigidly limits the territory eastward in which they can compete. Industry in the United States grew and throve on the home market. Export trade has always been of smaller moment to American producers than to those of the United Kingdom, France or Germany. This difference arose from the constant expansion of our population and the breathless haste in exploiting the wealth of the Continent.

The home market for Coast manufacturers is not the continental United States but approximately the western half of it. This will always be the more sparsely populated section of the continent. Natural conditions make it impossible for the arid sections of the Far West to support a population anywhere near proportionate to their area. Seven Western States had fewer than 6 people to the square mile in 1919, while the average for the United States was more than 35 to the square mile. The civilization of Utah depends upon an irrigated area of 1,371,000 acres, out of a total of 53,000,000 acres. Nevada has an average rainfall of less than 10 in. a year. Irrigation, when it has done its utmost, probably cannot reclaim more than 5 per cent of the arid land in any one of the Western States. At best, it can merely establish oases of intensive farming in wide stretches of desert. Arid States can produce a surplus of food products, but they cannot supply sufficient drinking-water for a large population. The possible home-market will not be sufficient to support the full development of Coast manufacturing.

It is claimed that low freight-rates through the Panama Canal permit southern Coast cities to offer their products in New York City in competition with goods from Buffalo or to compete in Philadelphia with goods from Pittsburgh. Because of the localization of much manufacturing close to the Atlantic coast, the cases in which such competition of the West with the East is profitable are few in number.

Panama Canal records show that in 1921 and 1922 tonnage from the Atlantic coast to the Pacific in intercoastal trade was slightly exceeded by shipments from the Pacific to the Atlantic. Total intercoastal tonnage in 1922 more than doubled that of the preceding year. In the entire traffic through the Canal for 1922 the most remarkable gains were in the trade of the Pacific coast of North America.

In the foreign market there is no handicap for the rising industries of the Coast, rather a distinct advantage of location as regards Oriental trade. Facilities for trade are constantly improved; for instance, by the 'round-the-world shipping service to begin in 1924 and plans for direct radio communication between San Francisco and Shanghai. Seven per cent of United States exports in 1921 and 8 per cent in 1922 were shipped from Pacific coast ports.

In imports a better place has been attained by the Coast ports. In 1922 nearly 14 per cent of all imports of merchandise were entered there, a share that represents a notable gain over 7 per cent in 1921. As regards the imports from Asia and Oceania, the position is more favorable; about 18 per cent in 1920 and 16 per cent in 1921 came to the Pacific coast. Japan and the Philippines sent the largest values.

The achievement of Pacific coast industries in the short time of their existence is a striking example of effective enterprise. Their further advance will be determined by the growth of the local market and the unlimited possibilities of foreign trade.—*Commerce Monthly.*

Officers of the Society

AT the annual meeting of the Society held last month a President; a First Vice-President; five Second Vice-Presidents representing motor-car, tractor, aviation, marine and stationary internal-combustion engineering respectively and three Councilors were elected and the Treasurer was reelected. In addition to these officers the three Councilors elected at the 1923 Annual Meeting for the full term of 2 years and the last Past-President are voting members of the Council for 1924. Such photographs of the officers and Councilors as it was possible to secure are presented on the following pages and their careers are outlined below.

H. M. Crane

President Crane was born on June 16, 1874. He received his education in private schools, with a final year at Phillips Exeter Academy, being graduated in 1891. He was graduated from Massachusetts Institute of Technology in 1895 with the degree of Bachelor of Science in Mechanical Engineering and in 1896 with a similar degree in Electrical Engineering,

After graduating he joined the laboratory force of the American Telephone & Telegraph Co. in Boston and worked there 2 years. In 1898 he was transferred to the engineering department of the Western Electric Co. in New York City, where he worked first on the preparation of telephone switchboard installation specifications and later on the development of apparatus and circuits. In 1905 he left the engineering department to become engineering assistant to H. B. Thayer, general manager of the company, and the following year resigned from the company.

In 1906 Mr. Crane organized the Crane & Whitman Co. in Bayonne, N. J., for the development of gasoline automotive machinery and especially motor cars. This company later became the Crane Motor Car Co., and in 1914 was consolidated with the Simplex Automobile Co. He was president of the Crane Motor Car Co. and vice-president of the Simplex Automobile Co.

In 1916 the Wright-Martin Co. was organized and absorbed the Simplex company. Mr. Crane became vice-president in charge of engineering and remained in this position after the reorganization of the company as the Wright Aeronautical Corporation, about Jan. 1, 1920. He resigned from the latter company in March, 1920, and for the remainder of the year was not engaged in any regular business but did some consulting work. During 1922 he was engaged in the development of a new passenger-car. On July 30, 1923, he was appointed technical assistant to the president of the General Motors Corporation.

Mr. Crane has taken a prominent part in the work of the Fuel Committee of the Society and as Chairman of its Research Committee and the Aeronautic Division of the Standards Committee. He is a member of the Tire and Rim Division for 1924. At the 1920 Annual Meeting of the Society he was elected Second Vice-President representing aviation engineering and a Councilor at the 1922 Annual Meeting of the Society and served as First Vice-President for the last administrative year, having been elected to that office at the 1923 Annual Meeting.

E. A. Johnston

First Vice-President Johnston was born at Brockport, N. Y., Aug. 1, 1875. After receiving a public school education he entered the Chicago Business College. From 1890 until 1894 he was employed by the Johnston Harvester Co., Batavia, N. Y., serving in all departments including wood and metal pattern-making, blacksmithing, machine shop and foundry. In 1894 he accepted a position as pattern-maker with the McCormick Harvester Co., and has been continuously employed by its successor, the International Harvester Co., and its subsidiary organizations as machinist, designer, experimental engineer, foreman, superintendent and manager of the experimental department. He now holds the position of director of engineering.

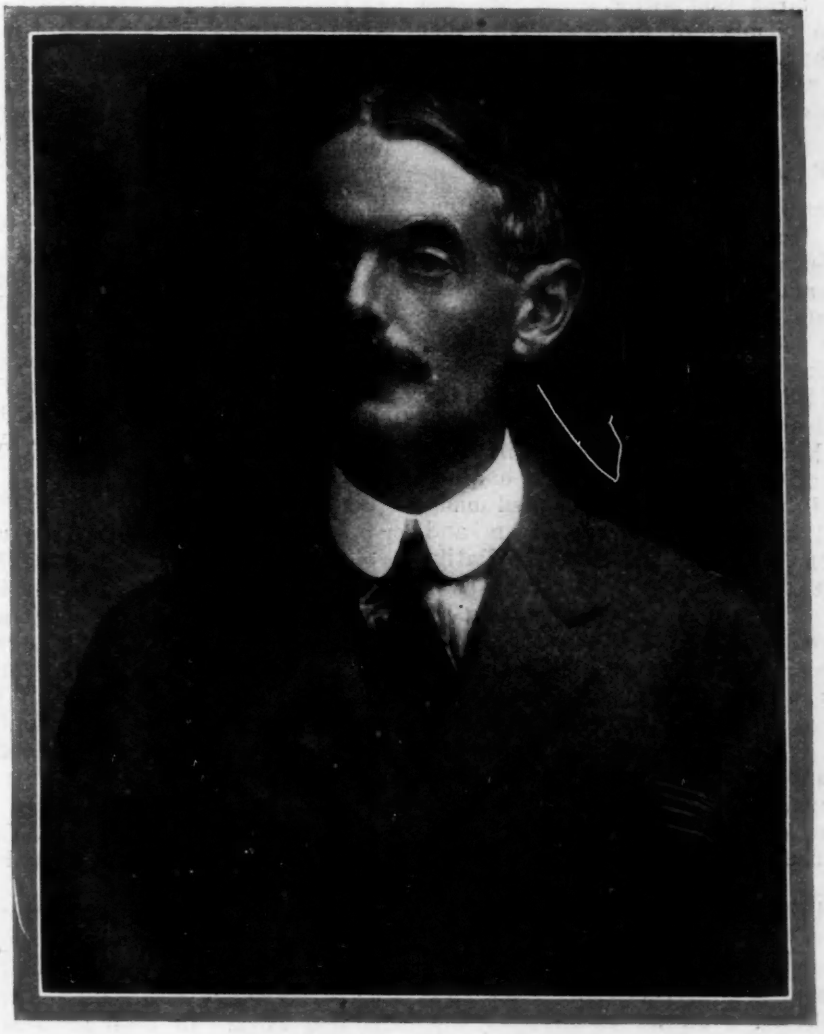
Mr. Johnston was Chairman of the Tractor Division of the Standards Committee in 1920 and 1921, and has been Chairman of the Standards Committee since 1922. He has had a very wide experience in electrical and mechanical engineering and research work related thereto. He was elected a Councilor at the 1919 Annual Meeting and Second Vice-President representing tractor engineering at the 1921 Annual Meeting of the Society.

W. R. Strickland

Second Vice-President Strickland, representing motor-car engineering, was born in 1875 at Cincinnati. He received his education at the Chicago Manual Training School and at the Massachusetts Institute of Technology from which he was graduated with the degree of Bachelor of Science in 1898. Immediately after graduation he entered the Navy as an assistant engineer with the rank of ensign and served at the Mare Island Navy Yard on the Pacific coast and in the Hawaiian Islands on the U. S. S. Bennington during the Spanish-American War.

Until September, 1899, he was employed as a draftsman by the Blake Pump Co., Cambridge, Mass., and the Buckeye Engine Co., Salem, Ohio. From September, 1899, to January, 1901, he was a designer of electric traveling-cranes and chief engineer of the Case Mfg. Co. of Columbus, Ohio. At that time he became interested in railroad work, entering the service of the Colorado Fuel & Iron Co., Denver, Colo., where he was engaged in railroad location work in connection with the opening up of coal mines and marble quarries. In 1902 he became associated with the New York Central & Hudson River Railroad on railroad location and construction, general engineering, maintenance, bridge and building work. In 1904 he was assistant secretary of J. G. White & Co., New York City, and was superintendent of construction on hydraulic and electric development at San Juan, P. R., leaving there in February, 1908. In July of that year he secured the position of mechanical engineer and assistant manager of the Detroit plant of the American Radiator Co., and had charge of the operation and improvement of the continuous molding plant and machining department.

In 1911 he became assistant engineer with the Peerless Motor Car Co., Cleveland, where he was engaged in the perfecting and developing of four, six and eight-cylinder engines and truck and car chassis with bodies and fit-



H. M. CRANE

tings. He was made chief engineer of this company in 1913. In the fall of 1921 he resigned this position and subsequently became associated with the Cadillac Motor Car Co. in a similar capacity, a position that he now holds.

Mr. Strickland was elected to Member grade in the Society Jan. 5, 1912. He served as Treasurer of the Cleveland Section for the administrative year 1916-1917 and was elected Chairman of the Section the following year. In 1921 Mr. Strickland was Vice-Chairman of the Standards Committee, Chairman of the Ball and Roller Bearings Division of that Committee and Chairman of the Sectional Committee on Ball Bearings of the American Engineering Standards Committee. For the last 2 years he has been a member of the Ball and Roller Bearings Division of the Standards Committee was reappointed for 1924. At the 1922 Annual Meeting of the Society he was elected a Councilor to serve during that administrative year.

J. F. Max Patitz

Second Vice-President Patitz representing tractor engineering was born at Muegeln, Saxony, Germany, May 21, 1866. After completing a course in the Royal High School at Dresden he emigrated to the United States in 1881. The first 4 years that Mr. Patitz spent in the United States were in factories and machine shops in Pittsburgh and its vicinity. In June, 1885, he entered the service of the E. P. Ellis Co. at Milwaukee, eventually becoming one of its designing engineers. When this company was absorbed by the Allis-Chalmers Co. in 1900, he was first in charge of the building of steam engines and air compressors and during this time designed many improved features that are now found on steam and compressed air machinery. In 1902 and 1903 Mr. Patitz paid an extended visit to Europe where he made a thorough investigation of the design and operation of steam turbines and gas engines. A second trip to Europe was made in 1913 at which time he studied the new type of soil tilling machines in use in France and Germany. When the Allis-Chalmers Co. entered the tractor field the following year, Mr. Patitz paid especial attention to this phase of the company's activities since he had been interested in the development of machinery for cultivation since 1911. At the present time Mr. Patitz holds the position of chief consulting engineer with the Allis-Chalmers Mfg. Co.

Mr. Patitz was elected to Member grade in the Society, March 14, 1917. He was a member of the Agricultural Power Equipment Division of the 1923 Standards Committee and is Chairman of that Division for 1924. In 1891 Mr. Patitz was elected a Junior member of the American Society of Mechanical Engineers and became a member of that Society in 1900. He is also a member of the American Society of Agricultural Engineers.

H. L. Pope

Second Vice-President Pope representing aviation engineering was born at Newton, Mass., Nov. 5, 1879. He received his early education at the Peekskill Military Academy and was graduated from the Massachusetts Institute of Technology in 1902 with the degree of Bachelor of Science in Mechanical Engineering.

After serving as an apprentice in the shops and drawing office of the Pope Mfg. Co., Hartford, Conn., he became assistant superintendent, holding this position for 2 years and being transferred at the end of that time to the post of factory manager at the Hagerstown, Md., plant of the same organization where he also remained for 2 years. In 1907 Mr. Pope became factory manager of the Pope Motor Car Co. at Toledo and after remaining there for 2 years, accepted a similar position with the Matheson Motor Co., Wilkes-Barre, Pa.

In 1910 he returned to the Pope Mfg. Co. at Hartford and remained there for 4 years as factory manager, leaving at the expiration of that time to become associated with the Ferro Machine & Foundry Co. at Cleveland in a similar capacity. This position he held for 2 years.

Vice-President Pope's active connection with aeronautics began in 1916 when he joined the forces of the Wright-Martin Aircraft Corporation and went to Los Angeles, Cal., as factory manager on the construction of the R-1 and the J-1 training planes for the Government. In July, 1918, he went to England and France to supervise the installation of the Hispano type engines that the Wright-Martin corporation was building at that time for installation in British S.E.-5 fighting airplanes. While superivising the installaton of these engines he also acted in a consulting capacity with regard to changes in the design of the airplanes in which these engines had to be mounted. When the Wright Aeronautical Corporation was formed in 1920 and its plant at Paterson, N. J., was established, he was appointed factory manager and at the present time is in charge of manufacturing activities on both airplanes and engines.

Mr. Pope was elected to Member grade in the Society on July 12, 1910. He has been Chairman of the Nomenclature Division of the Standards Committee since 1922 and is Vice-Chairman of the Aeronautic Division for 1924.

W. C. Ware

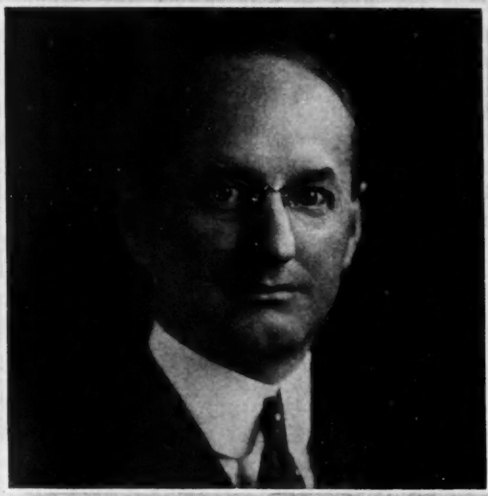
Second Vice-President Ware representing marine engineering was born at Dayton, Ohio, March 7, 1880. His early education was received in the public schools of his birthplace and after being graduated from the Steele High School of that city, he became associated with the firm of W. P. Callahan & Co., builders of stationary gas and gasoline engines located at Dayton, in the capacity of assistant to the superintendent of the foundry and the pattern shop. Here he remained for the 3 years from 1898 to 1901.

In the latter year Mr. Ware went with the Fay & Bowen Engine Co., Geneva, N. Y., builder of marine and stationary gasoline engines, and has been associated with the organization ever since. For the first 5 years he had charge of foundry and pattern-shop work as well as spending considerable time on gasoline engine design. In 1904 he became a stockholder in the company and was elected secretary but still retained his interest in mechanical work. In 1906 he became allied more closely with shop management and designing and in 1911 was elected vice-president and general superintendent in charge of designing and manufacturing. He was subsequently elected president and general manager of the Company, a position that he still holds.

Mr. Ware was elected to Member grade in the Society, March 12, 1915. Following the declination of E. J. Hall to serve as Second Vice-President representing marine engineering for the last administrative year, Mr. Ware was appointed to fill the vacancy. He has been a member of the Engine Division of the Standards Committee for the last 2 years and is Vice-Chairman of that Division for 1924.

Thomas B. Fordham

Second Vice-President Fordham representing stationary internal-combustion engineering was born at New York City, April 11, 1891. He was graduated from



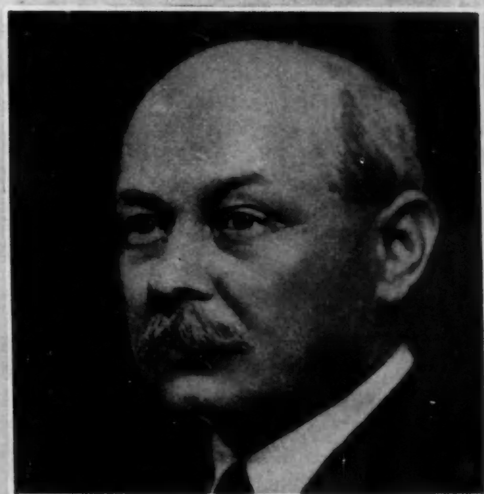
W. R. STRICKLAND

E. A. JOHNSTON

T. B. FORDHAM

H. L. POPE

H. W. ALDEN



J. F. MAX PATITZ

the New York University in 1912, subsequently pursued special studies at Columbia University for 2 years and then attended the New York Law School.

Prior to the war he was engaged in industrial engineering work at Chicago with the firm of J. Lee Nicholson & Co. and during the war was supervisor in the Finance Section of the Ordnance Department. When mustered out of the service in March, 1919, he again became connected with Nicholson & Co. in the capacity of an industrial engineer and a member of the firm. Since September, 1920, Mr. Fordham has been superintendent of the Delco-Light Co., Dayton, Ohio, in charge of manufacturing operations.

Vice-President Fordham was elected to Member grade in the Society, Jan. 9, 1923. He is also a member of the Society of Industrial Engineers.

A. K. Brumbaugh

Councilor Brumbaugh was born at Hagerstown, Md., Dec. 29, 1883. He received his education at the Baltimore Polytechnic Institute, Baltimore, and Lehigh University, receiving the degree of electrical engineer at the latter institution in 1909.

Mr. Brumbaugh's experience is varied dating from March, 1898, when he entered the service of the Crawford Mfg. Co., bicycle manufacturer at Hagerstown, Md., as a toolroom apprentice. Here he remained for a little over 3 years, leaving in April, 1901, to become a fireman on the Western Maryland Railroad. After serving in that capacity for 7 months he was transferred to the civil engineering department of the railroad, resigning in September, 1902, to enter the Baltimore Polytechnic Institute, where he studied until June, 1904. From that time until September of the following year and from February to September, 1906, he was connected with the electrical department of the Baltimore & Ohio Railroad.

His connection with the automotive industry dates from 1907, when he became associated with the Loane Hiltz Engineering Co., motorboat builder, where he did designing, testing and sales work. In 1909 and 1910 he was engaged in the development of vehicle motors by the Westinghouse Electric & Mfg. Co., leaving in June of the latter year to become engineer for the Maryland Casualty Co. of Baltimore. He remained with this organization until February, 1914, being engaged in the bonding department and also doing construction and executive work. In February, 1914, Mr. Brumbaugh went with the Consolidated Gas & Electric Co., also of Baltimore, where he had charge of the administration and maintenance of transportation equipment. In 1915 he entered the service of the Autocar Co. as assistant engineer, doing sales and engineering work. This connection has been continued to the present time, his appointment as electrical engineer for the Company having been made last fall.

Mr. Brumbaugh was elected to Member grade in the Society Feb. 16, 1916. He was Chairman of the Truck Division of the Standards Committee in 1921, has served as a member of the Division for the last 2 years and has been appointed to that Division and also to the Storage Battery Division for 1924. In 1922 Mr. Brumbaugh was Chairman of the Sections Committee of the Society.

W. A. Chryst

Councilor Chryst was born in Dayton, Ohio, Oct. 21, 1877. His early education was received in the public schools of his birthplace and also in the night schools conducted by the Young Men's Christian Association.

In 1892 he became associated with the National Cash Register Co. and served in various capacities, having charge of one of its inventions department in 1911, when he became chief engineer of the Dayton Engineering Laboratories Co. Mr. Chryst has been engaged since 1909 in the design of electrical equipment for automotive purposes, including the earliest types of starting, lighting and ignition apparatus developed by the Dayton company.

He was elected to Member grade in the Society on July 29, 1912. Since January, 1917, Mr. Chryst has been a member of the Electrical Equipment Division of the Standards Committee since 1921 and served as one of the Vice-Chairmen of the Committee in that year.

F. W. Gurney

Councilor Gurney was born April 21, 1867, at New Braintree, Mass., and was educated at Oberlin College, being graduated therefrom in 1891 with the degree of Bachelor of Arts. After leaving college he invented a machine for turning out wooden bowls which were manufactured by the Gurney Mfg. Co. in the South. Shortly after this Mr. Gurney invented a wood split pulley that was also produced by this company.

His connection with the automotive industry dates back to the winter of 1900 when he went to Jamestown, N. Y. The following summer he became interested in ball bearings and in the fall of 1903 organized the Gurney Ball Bearing Co., of which he is chief engineer.

Mr. Gurney was elected to Member grade in the Society Sept. 10, 1917. He has been Chairman of the Ball and Roller Bearings Division of the Standards Committee since 1922 and is a member of the Axle and Wheels Division for 1924.

J. H. Hunt

Councilor Hunt was born at Saranac, Mich., March 24, 1882, and received his technical education at the University of Michigan, being graduated from that institution in 1905 with the degree of Bachelor of Science in Electrical Engineering.

After graduation Mr. Hunt went with the Western Electric Co., for a year being engaged in the design of dynamo electric machinery in its engineering department. The next year was spent as an instructor in electrical egineering at Washington University, and from that institution he went to the electrical engineering department of the Ohio State University, where he remained until 1912, being successively assistant professor of electrical engineering for 1 year, associate professor for 3 years and professor for 1 year. From 1909 to 1911 he had charge of the department although having the title of associate professor.

Councilor Hunt's connection with the automotive industry began in 1912 when he accepted a position as electrical engineer for the Packard Motor Car Co. He remained there for about a year in the carriage chassis engineering department and was engaged with the design of electrical installation. In 1913 he entered the service of the Dayton Engineering Laboratories Co. as research engineer, where he was interested principally in development work on ignition equipment although touching all phases of electrical installation on motor cars. He subsequently became head of the electrical division of the General Motors Research Corporation and holds that position at the present time.

Mr. Hunt was elected to Member grade in the Society Jan. 4, 1916. When the Dayton Section was organized in 1921 Mr. Hunt was elected Vice-Chairman and was

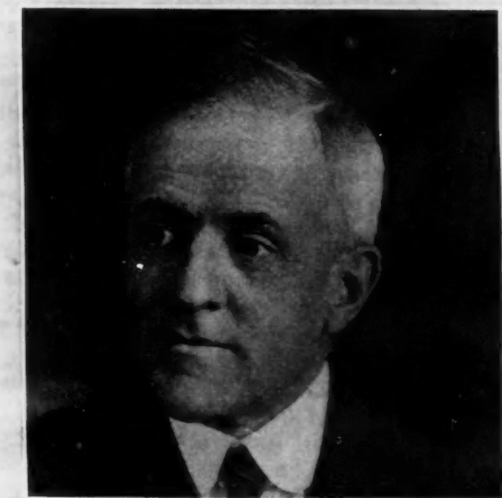
M. P. RUMNEY

A. J. SCAIFE

J. H. HUNT

W. A. CHRYST

F. W. GURNEY



C. B. WHITTLESEY

named by the Section as its alternate representative on the committee appointed to nominate officers of the Society for the 1922 administrative year. He was elected Chairman of the Dayton Section in May, 1922.

MASON P. RUMNEY

Councilor Rumney was born in Detroit Dec. 4, 1883. He attended school in Detroit and Kalamazoo and graduated from the high school of the latter city. He entered the University of Michigan in the fall of 1903 and was graduated as a mechanical engineer 4 years later. In addition Mr. Rumney specialized in metallurgy and chemistry.

After leaving college he entered the service of the Detroit Steel Products Co. and was sent to Europe for 8 months to learn the manufacture of a new product. On his return to the United States, Mr. Rumney entered the engineering and sales department, introducing this product. After this he became superintendent, works manager and assistant general manager and is now Vice-President of the Detroit Steel Products Co. During the war he was a Major in the office of the Chief of Ordnance at the City of Washington in charge of the production of vehicles and the assembly of field artillery.

Mr. Rumney was elected to Associate grade in the Society on May 17, 1912, and transferred to Member grade Jan. 9, 1923. In 1922 he was a member of the Meetings Committee and last year served as its Chairman. Mr. Rumney has been a member of the Iron and Steel Division of the Standards Committee for the last 2 years. He is also a member of the American Society for Testing Materials and the Detroit Chapter of the American Society of Steel Treaters.

A. J. SCAIFE

Councilor Scaife was born in England in 1875 and 5 years later came to America and settled with his family at Cleveland. His early education was received in the grammar and high schools in the vicinity of Cleveland. In 1895 Mr. Scaife's business career began as an apprentice in the toolroom of the A. L. Moore Co., Cleveland. In the fall of 1897 he entered college, but the following summer returned to the toolroom of the stamping department of the Cleveland Machine Screw Co., which had succeeded the Moore organization.

In the fall of 1899 he was employed by the Parish & Bingham Co., Cleveland, as a toolmaker and in November of the following year entered the service of the White Sewing Machine Co. as a toolmaker in its automatic department. In the spring of 1901 Mr. Scaife was transferred to the testing department and later to the drawing room and experimental department where he remained until 1907, when the name of the organization was changed to the White Co. For the next 7 years he was employed in the engineering department of the White Co., having charge of the testing and carbureter departments and also doing some development work. From 1918 to 1921 Mr. Scaife was consulting engineer for the White Motor Co., which was organized in 1914 to succeed the White Co. Since the fall of 1921 he has been factory service engineer in charge of field service for this company.

Mr. Scaife was elected an Associate of the Society on Dec. 23, 1910, and was transferred to Member grade Oct. 1, 1911. He served as a member of the Truck Division of the Standards Committee from 1918 to 1921 inclusive, was Vice-Chairman of the Division in 1922 and has been Chairman since 1923. He is also a member of the Lighting and the Tire and Rim Divisions for 1924. When the Cleveland Section was organized in 1915 Mr. Scaife was elected its first Treasurer and was Chairman of the Section for the year 1916-1917.

H. W. ALDEN

Past-President Alden was born at Lynndonville, Vt., Dec. 20, 1870. He received his technical education at the Massachusetts Institute of Technology, being graduated from the mechanical engineering course in 1893. For the next 2 years he was associated with the American Projectile Co., Lynn, Mass., in the capacity of engineer.

His connection with the automotive industry dates back to 1895, when he became associated with the Pope Mfg. Co., Hartford, Conn., as an engineer on experimental work. When the Pope organization subsequently became the Electric Vehicle Co., Mr. Alden retained his position until 1906. At that time he became chief engineer of the Timken Roller Bearing Axle Co., Canton, Ohio, and 3 years later helped to organize the Timken-Detroit Axle Co., being made its chief engineer and moving from Canton to Detroit. In 1914 Mr. Alden was elected Vice-President of this company and in December, 1922, was made chairman of the board of directors.

In June, 1917, he was commissioned a Major in the Ordnance Department and was detailed to take charge of the development of tanks. In September of that year he sailed for France to study tank warfare and cooperate with the French and the English Governments in the development of tanks. After remaining abroad for 4 months he returned to the United States in January, 1918, to supervise the engineering work of the program that had been worked out abroad. In February of the following year he was discharged from the service and in July, 1919, received the Distinguished Service Medal for representing the United States Government in France and England on tank matters and for the development of new tank-designs.

Mr. Alden was elected to Member grade in the Society on March 15, 1905. Following the death of the late Henry F. Donaldson in 1912, he served as President of the Society for the latter half of that year, and was elected to that office at the 1923 Annual Meeting. Mr. Alden is also a member of the Ordnance Advisory Committee of the Society. He was elected to membership in the American Society of Mechanical Engineers in 1908.

CHARLES B. WHITTELSEY

Treasurer Whittelsey has been connected with the Hartford Rubber Works Co. since 1901, beginning as its purchasing agent. In 1905 he was made assistant to the general manager; in 1906, superintendent; in 1911, secretary and factory manager; in 1915, Vice-President and factory manager; and in 1916, President and factory manager. He served as President of the Hartford Chamber of Commerce and of the Hartford County Manufacturers' Association and at present is a director of the Manufacturers' Association of Connecticut.

Mr. Whittelsey was elected to Member grade in the Society in 1910. In 1916 he was elected a Life Member. He was a member of the Standards Committee for several years, beginning in 1911, and served as Chairman of the Tire and Rim Division in 1918 and 1919. Mr. Whittelsey was a member of the Council in 1912 and 1913 and was elected Treasurer in 1918, being reelected each year since. At the 1912 Annual Meeting he delivered a paper on Solid Motor Tires, and at the 1915 Annual Meeting presented a paper entitled the Pros and Cons of Tire Inflation.

Rust Resistance of Nickel-Plated Steel

By EDWIN M. BAKER[1]

ANNUAL MEETING PAPER

Illustrated with DRAWINGS AND PHOTOGRAPHS

THE quality of plated steel may be tested by exposing the article to the action of a salt spray and noting the appearance at intervals. A numerical method of rating the appearance is presented, and the rust resistance of steel plated with nickel and copper is shown to be dependent on the thickness of the plating. The effect on the salt-spray resistance of some common variables in nickel-plating, such as boric acid, ferrous sulphate, current density and defective steel, is disclosed and charted. The need of close technical control of the plating process is indicated, and some of the advantages of controlled electroplating at high current-densities are set forth.

IN recent years electroplating has become a process of increasing interest to the automotive engineer and, in particular, to the manufacturer of automobile parts and accessories. Steel, brass, aluminum and various alloys are electroplated either to give the article a more pleasing appearance, or to protect the base metal from corrosion, or both. In the case of most ferrous alloys protection from corrosion is of prime importance, since the appearance of the article will no longer be pleasing after corrosion of the base metal has commenced and the article has become noticeably rusted.

Electroplated metals are of necessity either electropositive or electronegative to the base metal, and the metals that can be electroplated are commonly classified on this basis. Zinc and cadmium are examples of metals electronegative to steel, and nickel, copper and alloy brass are common examples of electropositive coatings. When only one electrodeposit is applied, it is well recognized that electronegative coatings form an ideal protection,[2] though the value of an electronegative coating covered by an electropositive coating is open to discussion.[3]

Electronegative coatings may be porous and still protect the base metal in some measure by electrolytic action, the coat corroding instead of the base metal. However, electropositive coatings induce electrolytic corrosion of any exposed portions of the base metal and must not be porous if good protection is to be afforded.

Electronegative coatings are ordinarily used for articles that must be well protected, provided a high finish is not required. Electropositive metals, and nickel in particular, are used on articles requiring a polished finish; and the quality of the plating must then be such as to give the required protection despite unfavorable electrolytic forces.

BUREAU OF STANDARDS SALT-SPRAY TEST

A number of methods of judging the effectiveness of the coating in protecting the base metal have been proposed. Actual exposure to service conditions is the best test, as judged from the standpoint of the test's being representative of the use to which the metal is to be put, but this requires too much time. The salt-spray method of testing coatings, as recommended by the Bureau of Standards,[4] is probably the best accelerated test, though, so far as I am aware, very little work has been done on the correlation of any accelerated method of testing and service performance. The method recommended by the Bureau of Standards is as follows:

> The test as conducted at the Bureau of Standards is made in an Alberene stone box, with a glass cover and glass supports for the samples. The construction is indicated in Fig. 1. The stone box is inclined so that drops of solution collecting on the cover will run down to the edge instead of dripping on the samples.
>
> A 20-per cent solution, by weight, of commercial sodium-chloride, 20 grams of salt and 80 grams of water, or 2 lb. of salt and 1 gal. of water, filtered if necessary, is used, and with an air-pressure of about 6 or 7 lb. per sq. in., a very fine mist is produced.

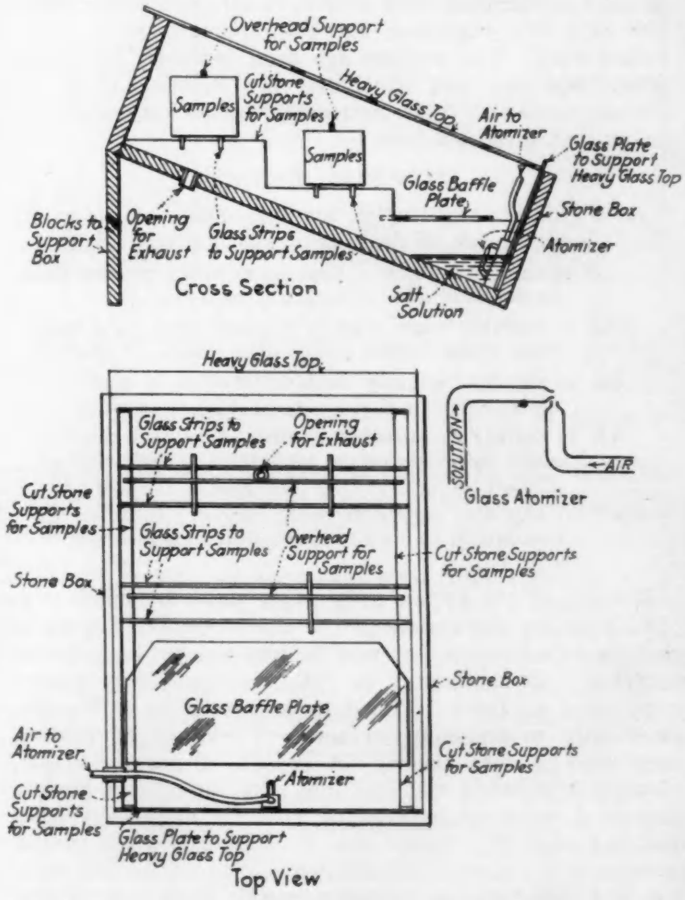


FIG. 1—CROSS-SECTION AND PLAN VIEW OF THE SALT-SPRAY BOX FOR ACCELERATED CORROSION TESTS

This Box Which Is Recommended by the Bureau of Standards Is of Alberene Stone with a Glass Cover for Ready Observation of the Progress of the Test and Glass Supports for the Samples Being Tested. The Box Is Tilted So That Any Drops of the Solution Collecting on the Cover Will Run Down to the Lower Edge Instead of Dripping on the Samples

[1] Assistant professor of chemical engineering, University of Michigan, Ann Arbor, Mich.

[2] See Protective Metallic Coatings for the Rust-Proofing of Iron and Steel, Bureau of Standards Circular No. 80.

[3] See Protective Electroplating by M. Meredith, published in *Machinery*, vol. 23, p. 906; see also Protection of Iron by Electroplating, by O. P. Watts and P. L. DeVerter, published in the *Transactions of the American Electrochemical Society*, vol. 30, p. 145.

[4] See Protective Metallic Coatings for the Rust-Proofing of Iron and Steel, Bureau of Standards Circular No. 80.

The samples, after being washed with gasoline and ether to remove all grease, are placed in the spray-box in a vertical position on the glass rods or strips. They are removed from the bath every 24 hr., washed with water, using a moderately stiff bristle brush, and after drying are carefully examined for the presence of red and yellow iron rust. The first appearance of rust indicates the conclusion of the test, but *valuable information may be obtained by continuing the test and observing the extent of the corrosion produced by longer exposure.*

The italics in the quotation are mine.

Proposed Modified Salt-Spray Test

An investigation of the rust resistance of nickel-plated bumpers, conducted jointly with Herbert Jandus, has convinced me that the best practical results are obtained by continuing the test until the article has rusted to an extent such that rust would be noticeable to the user. Of two articles tested in the salt spray, the article that first shows a slight degree of rust may develop further rust much more slowly, and thus be, in fact, of superior quality. A method of registering and rating observations is a prerequisite for continuing the test. The method devised for rating the resistance of nickel-plated bumpers has been in use for almost 2 years and is believed to have sufficient merit to justify a more general use and presentation before the Society.

Articles to be plated are tested according to the Bureau of Standards' recommendation, but are removed from the spray every 8½ hr., are washed with hot water, using a moderately stiff bristle brush, and after drying are carefully examined for the appearance of red or yellow rust. The articles are then replaced in the salt spray and the test continued for subsequent 8½-hr. periods until the "very noticeably rusted" stage, defined below, has been reached.

Salt-Spray Rating

As a guide in registering the appearance of the article the following scale of degrees of rusting was adopted.

P to signify "perfect," that is, no trace of rust can be detected after the closest scrutiny

VSR to signify "very slightly rusted," that is, a very close examination shows only traces of rusting

SR to signify "slightly rusted," that is, a close examination would show distinct signs of rust

NR to signify "noticeably rusted," that is, a moderately close inspection would show the presence of rust

VNR to signify "very noticeably rusted," that is, the rust would be plainly discernible at a distance of 3 or 4 ft.

Rusting of the article at a single point is sufficient to justify rating the article at the corresponding degree of rusting. Ordinarily, interest is attached to the polished surfaces, and these may be rated independently of the unpolished surfaces. The data presented in this paper refer only to polished surfaces. The scale of rusting here used is very severe. A person of normal vision, viewing a polished surface in a good light, can plainly discern a very slight spot of rust on an article at a distance of 4 ft. Hence the *VNR* stage by no means represents a complete breakdown of the protective coating and, in fact, by using a metal polish an article rusted to the *VNR* stage may usually be made to appear perfect. Rating an article on a single point of rust may seem unfair, especially when large and small surfaces are compared. According to the law of probabilities, a single defect is more likely to appear on a large surface than on a small one. In this sense a large test specimen is at a disadvantage, yet if a specimen shows *NR*, for example, at a single point, many points on the specimen generally show a slightly lower degree of rusting, as *SR* or perhaps *VSR*. That this must be true is indicated by the correlation of test results shown in the tables and the figures given in the latter part of this paper.

To admit of numerical comparisons of the relative rust-resisting qualities of various specimens, an arbitrary system of rating is used. Numerical values are assigned to evaluate the quality of the specimen according to its appearance after each period of exposure to the salt spray. The sum of the numbers, denoting the quality at each successive period until the *VNR* stage is reached, is taken as the "salt-spray rating" of the specimen. Table 1 gives the numbers assigned to evaluate the appearance at different periods. To illustrate the method of rating, if a specimen under test shows *P* the first period, *SR* the second period, *NR* the third period and *VNR* the fourth period, its salt-spray rating will be $4+3+3+0=10$.

TABLE 1—VALUES FOR SALT-SPRAY RATINGS[5]

	P	*VSR*	*SR*	*NR*	*VNR*
1	4	3	2	1	0
2	5	4	3	2	0
3	6	5	4	3	0
4	7	6	5	4	0
5	8	7	6	5	0
6	9	8	7	6	0
7	10	9	8	7	0
8	11	10	9	8	0
9	12	11	10	9	0

[5] The numbers in the first column denote 8½-hr. periods of exposure to the salt spray and the letters at the head of the different columns denote the appearance of the specimen being tested.

The graph presented in Fig. 2 shows the possible range of rating of an article that has maintained a degree of rusting less than *VNR* for any number of periods. The ordinates give the duration of the test in the number of 8½-hr. periods, and the abscissas give the salt-spray rating, computed as indicated. Obviously, the rating must lie between the *P* and the *NR* curves. It is a characteristic of this method of rating, which is perfectly arbitrary, that the numerical value of the rating rises rapidly with the increase of the duration of the test. This is rather desirable, inasmuch as the difficulty of producing a plating that will protect steel from rusting for a greater number of periods will increase in somewhat the same measure.

Part of the results of a salt-spray test of a number of plated articles are presented in Table 2. All the articles have the same nature of plating. It is at once apparent that entirely different impressions of the relative quality of the plating are gained from the salt-spray rating than would be given by the number of hours required to produce the first sign of rust. Judged from the salt-spray rating as proposed here, the order of excellence is *E, D, F, C, A* and *B*, whereas from the hours required to produce the first sign of rust the order is *F, E* and *A, B* and *C, D*. The difference is due to the fact that some platings may quickly assume the *VNR* stage after rusting has once set in, whereas other platings may be so constituted that the rate of rusting is much slower when once it has commenced, even though some imperfection, such as a pin hole or a possible inclusion of a particle of iron hydrate sludge in the plating, results in the early appearance of rust less pronounced than the *VNR* stage.

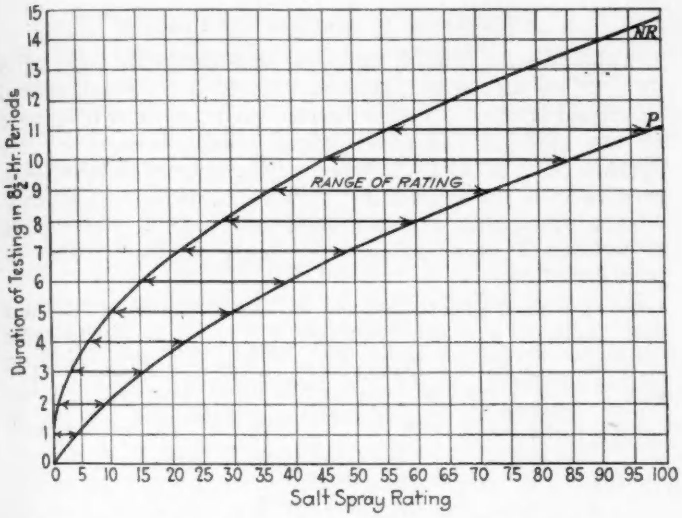


FIG. 2—POSSIBLE RANGE OF SALT-SPRAY RATINGS
The Range Covered by This Chart Is from Noticeably Rusty, the Upper Curve, Where a Moderately Close Inspection Would Show the Presence of Rust to Perfect, the Lower Curve, Where No Trace of Rust Could Be Detected on the Closest Scrutiny

I believe that this method of rating is more truly representative of the quality of the plating than is the number of hours that elapse before the first appearance of rust. The use of the article is continued long after rusting to the *VNR* stage and, in fact, it is doubtful if a less degree of rust is observed by the user.

FACTORS GOVERNING THE RUST RESISTANCE OF PLATED STEEL

A knowledge of the factors governing the quality of the plating is of even greater importance than is a method of rating the quality. A full discussion of these factors would necessarily be very extensive, and this discussion will be limited to a consideration of articles of steel that are finished with nickel and plated only with the electropositive metals, nickel and copper. This is a comparatively narrow field, yet it embraces most of the electroplatings that at present interest the automotive engineer. True, zinc or cadmium may be plated on the base metal, followed by nickel-plating, but in such a case any failure of the nickel plating results in the corrosion of the zinc or cadmium to a white incrustation instead of corrosion of the steel to a red or yellow rust, followed later by the rusting of the steel; hence, the quality of the nickel is important in this case also.

In general, it may be stated that the ability of the plating to protect the base metal from corrosion depends on the specific qualities of the plating and on its thickness. The quality of the product of any plating plant is judged not by the best work turned out but by the poorest, hence rigid technical control of the plating process is of great importance.

For plating on steel, the final or surface plating being buffed nickel, any of the following sequences of plating nickel and copper may be used.

(1) Plating nickel on steel and buffing
(2) Plating copper from a cyanide bath on the steel, then plating with nickel and buffing
(3) Plating nickel on the steel, plating with copper from either a cyanide bath or an acid copper-sulphate bath, then plating with nickel and buffing. The copper may or may not be buffed
(4) Plating as indicated in (2) and (3) and using various combinations or sequences of plating with nickel and copper

Plating is usually done as indicated in 2 and 3. The single plating of nickel indicated in 1 is likely to con-

TABLE 2—RESULTS OF SALT-SPRAY TESTS ILLUSTRATING THE LACK OF AGREEMENT BETWEEN THE SALT-SPRAY RATING AND THE TIME ELAPSING BEFORE THE FIRST APPEARANCE OF RUST

Duration of Test, 8½-Hr. Periods	*A*	*B*	*C*	*D*	*E*	*F*
1	*P*	*SR*	*SR*	*SR*	*P*	*P*
2	*VNR*	*NR*	*SR*	*SR*	*SR*	*P*
3		*VNR*	*SR*	*SR*	*NR*	*P*
4			*VNR*	*NR*	*NR*	*VNR*
5				*NR*	*NR*	
6				*VNR*	*VNR*	
Total time, hr.	17	24½	34	49	49	34
Rating	4	4	9	18	19	15

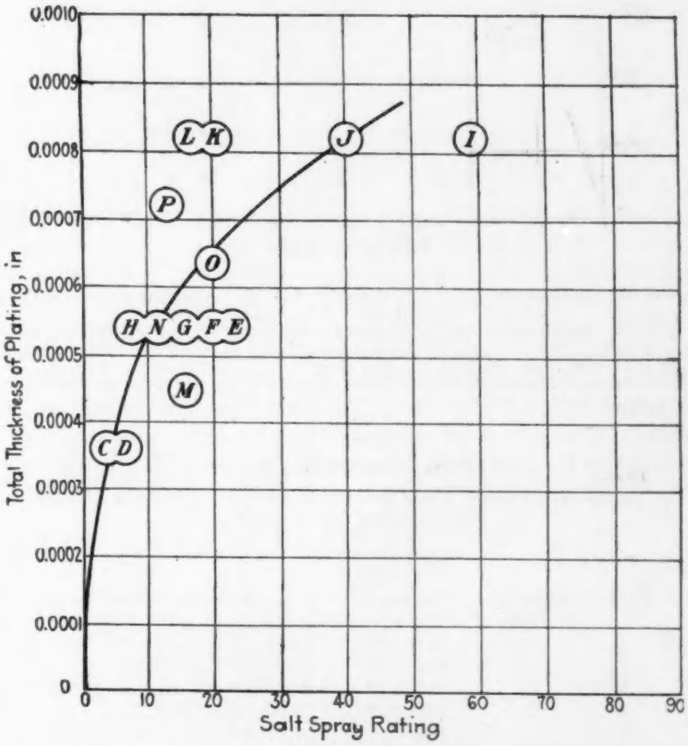


FIG. 3—EFFECT OF THE THICKNESS OF THE PLATING ON THE SALT-SPRAY RATING
These Experiments Were Made on a Number of Pieces of S.A.E. 1095 Steel. The Total Thickness of the Plating Was Calculated from the Current Density and the Time of Plating. The Letters in the Circles Refer to the First Column of Table 3 Which Gives the Conditions of Plating

TABLE 3—SALT-SPRAY RATING OF EXPERIMENTALLY PLATED STEEL

Point	Rating	Calculated Thickness of Plating, In.				Boric Acid, Oz. Per Gal.	Current Density, Amp. Per Sq. Ft.	
		Nickel	Copper	Nickel	Total		Nickel	Copper
C	4.0	0.000360	....	....	0.000360	7	100	....
D	5.0	0.000360	....	....	0.000360	2	100	....
E	19.5	0.000090	0.000270	0.000180	0.000540	2	50 to 200	12
F	17.0	0.000090	0.000270	0.000180	0.000540	4	200	12
G	15.0	0.000090	0.000270	0.000180	0.000540	6	200	12
H	7.0	0.000090	0.000270	0.000180	0.000540	8	200	12
I	59.0	0.000180	0.000270	0.000360	0.000810	2	200	12
J	40.0	0.000180	0.000270	0.000360	0.000810	4	200	12
K	20.0	0.000180	0.000270	0.000360	0.000810	6	200	12
L	17.0	0.000180	0.000270	0.000360	0.000810	8	200	12
M	16.0	0.000045	0.000045	0.000360	0.000450	2	100	100
N	12.0	0.000045 (*a*)	0.000045 (*a*)	0.000360	0.000540	2	100	100
O	20.0	0.000045 (*b*)	0.000045 (*b*)	0.000360	0.000630	2	100	100
P	13.0	0.000045 (*c*)	0.000045 (*c*)	0.000360	0.000720	2	100	100

(*a*) Plated with two coats of this thickness.
(*b*) Plated with three coats of this thickness.
(*c*) Plated with four coats of this thickness.

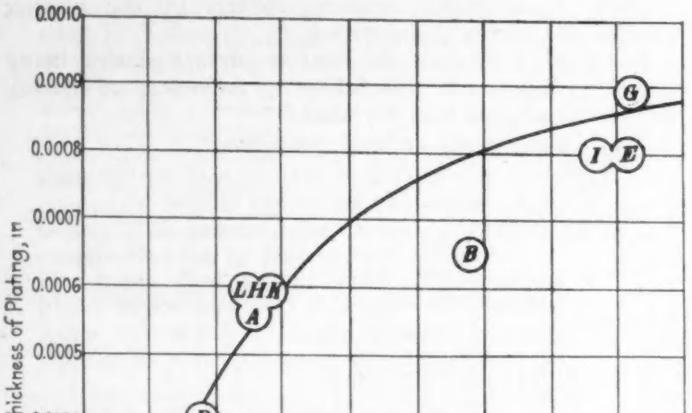


FIG. 4—EFFECT OF THE THICKNESS OF THE PLATING ON THE SALT-SPRAY RATING ON A NUMBER OF STEELS

The Pieces Used in These Experiments Were Various High-Carbon and Alloy-Steels That Were Plated in the Same Bath with Nickel and Nickel and Copper to Varying Thicknesses. The Letters in the Circles Correspond to Those in the First Column of Table 4 Which Gives Details of the Plating and the Steels Used

TABLE 4—SALT-SPRAY RATING OF VARIOUS STEELS PLATED UNDER THE SAME CONDITIONS, BUT WITH VARIOUS TOTAL THICKNESS OF PLATING

Point	Rating	Total Thickness of Plating, In.	Nature of Steel
A	26	0.00055	Duluth, S.A.E. 1095
B	58	0.00065	Gary, S.A.E. 1095
C	10	0.00028	Gary, S.A.E. 1095
D	18	0.00040	Pittsburgh, S.A.E. 1095
E	82	0.00080	Interstate, S.A.E. 1095
F	16	0.00026	Interstate, S.A.E. 1095
G	82	0.00090	Electric-Furnace, High-Carbon, 0.80 per cent carbon
H	25	0.00060	Electric-Furnace, S.A.E. 1095
I	77	0.00080	Chrome-Vanadium Spring
J	11	0.00035	Chrome-Vanadium Spring
K	28	0.00060	Chrome-Silico-Manganese Spring
L	25	0.00060	Open-Hearth Silico-Manganese Spring

tain pin-holes, and a process such as 4 is too complicated. Further, it can be demonstrated that nothing is gained by a great multiplicity of layers of deposits. Space and time do not permit a discussion here of the various merits of the different combinations nor of the details of plating conditions.

The effect of varying some of the conditions, namely, the thickness of the plating, and the effect of boric acid and of iron salts in nickel-plating baths on the quality of the plating, is presented by showing the effect of these variables on the salt-spray ratings of plated steel.

EFFECT OF THICKNESS OF PLATING

Table 3 and Fig. 3 present salt-spray ratings of a number of pieces of polished S. A. E. 1095 steel, plated in the laboratory. The ordinates give the total thickness of the plating, calculated from measurements of the current density and the time of plating. The abscissas give the salt-spray ratings as here proposed. The conditions of plating are indicated in Table 3, the letters of column 1 corresponding to those in the circles of points plotted.

Table 4 and Fig. 4 present salt-spray ratings on some high-carbon and alloy steels that were plated in the same baths, with nickel, copper and nickel, but with varying thicknesses of plating. The letters in the circles of the points plotted in Fig. 4 correspond to the letters in column 1 of Table 4.

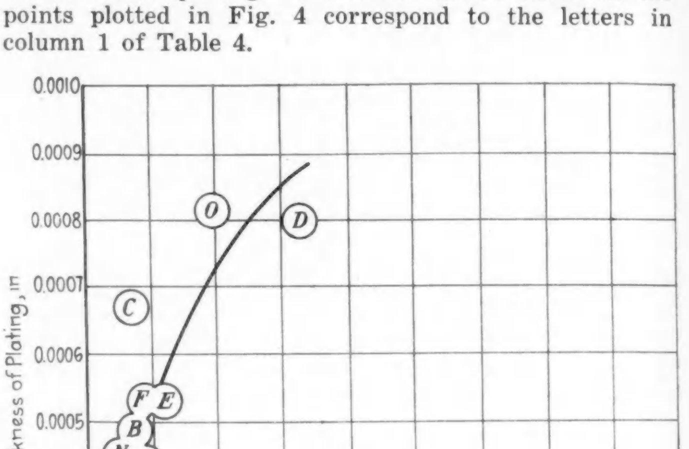


FIG. 5—EFFECT OF THE THICKNESS OF PLATING ON THE SALT-SPRAY RATING OF A NUMBER OF SPRING-STEEL BARS THAT WERE TYPICAL OF PRODUCTION IN A NUMBER OF PLANTS

The Details of the Plating and the Method of Determining the Thickness of the Plating Are Given in Table 5. The Letters in the Circles of the Chart Refer to the First Column of the Table. The Curves in Figs. 3 to 5 Establish the Strong Probability of a Very Close Relationship between the Thickness of the Plating and the Salt-Spray Rating Irrespective of Other Conditions. For the Same Thickness of Plating, the Experimentally Plated Specimens of Fig. 3 Show a Slightly Higher Rating Than the Steel Plated under Production Conditions

TABLE 5—SALT-SPRAY RATING OF STEEL PLATED IN VARIOUS PLANTS UNDER PRODUCTION CONDITIONS

Point	Rating	Thickness, In.	Method of Determining Thickness
A	4.0	0.00042	Computed
B	7.5	0.00049	Computed
C	7.5	0.00067	Computed
D	33.0	0.00080	Computed
E	11.5	0.00053	Computed
F	9.0	0.00053	Computed
G	9.0	0.00044	Measured
H	0.0	0.00024	Measured
I	3.0	0.00016	Measured
J	0.0	0.00016	Measured
K	0.0	0.00023	Measured
L	2.0	0.00028	Measured
M	4.0	0.00027	Computed
N	5.0	0.00045	Computed
O	20.0	0.00082	Computed

Table 5 and Fig. 5 present salt-spray ratings of a number of spring-steel bars plated in various plants and by various processes under production conditions.

Figs. 3 to 5, inclusive, certainly establish the strong probability, if they do not prove, that a very close relation exists between the thickness of the plating and the salt-spray rating, irrespective of other conditions. For the same thickness of plating, experimentally plated specimens show a slightly higher rating than steel plated under production conditions.

Effects of Boric Acid in Nickel-Plating Solutions

Other conditions, however, are not unimportant. Note for instance the spread in the ratings in Fig. 3 of the test-specimens *E*, *F*, *G* and *H* and *I*, *J*, *K* and *L*. The two series are plated under corresponding conditions as shown in Table 3, the concentration of boric acid in the nickel-plating bath being the only variable. Used boric acid is a component of most nickel-plating solutions. Fig. 6 presents the salt-spray ratings of these series, salt-spray ratings being plotted as abscissas and concentrations of boric acid in ounces per gallon, as ordinates.

Thus from the standpoint of salt-spray resistance the less boric acid used the better; but the more boric acid the nickel-plating solution contains the easier will the plating buff; therefore a suitable compromise must be made.

Effect of Iron in Nickel-Plating Solutions

Table 6 and Fig. 7 present data showing the effect of ferrous iron in nickel solutions on salt-spray ratings. A number of low-carbon steel samples were plated in the laboratory with nickel to a calculated thickness of 0.00036 in. Two current-densities were used, 36 and 50 amp. per sq. ft. Ferrous sulphate was added to give the concentrations of iron salt shown in the third column of Table 6. In Fig. 7 the salt-spray ratings are plotted as abscissas and the concentration of ferrous sulphate in ounces per gallon as ordinates.

From the data of Fig. 7 it follows that the solution should be free from iron. This is unqualifiedly true, as even a low concentration of iron salts in a nickel-plating solution will greatly increase the difficulty of buffing the plating to the desired color. Though I have no specific data to offer, I am firmly convinced that iron-hydrate sludge, which is almost always formed from iron in solution, is the cause of most of the erratic defects in the nickel plating that are evidenced by the low salt-spray ratings of work plated under conditions that would otherwise give a high quality of plating.

Nickel anodes contain as high as from 6 to 7 per cent of iron, though from 2 to 3 per cent of iron is representative of the better practice of today. Iron is added to cause the anodes to dissolve more readily. The same result may be attained by using a nickel-plating solution containing fluorides or chlorides. Under proper conditions electrolytic sheet nickel, containing less than 0.2 per cent of iron will dissolve with 100-per cent anode current efficiency. Iron in the anode dissolves with the nickel. Iron present in the solution in the ferric state will precipitate as ferric hydrate, if the acidity, or hydrogen ion concentration, of the solution is less than about 10^{-3} grams of hydrogen ion per liter of solution[6]. If iron is present in the ferrous state, however, the acidity must be less than 10^{-6} grams of hydrogen ion per liter to precipitate the iron as ferrous hydrate.

[6] See Effect of Iron on Electrodeposition of Nickel, by M. R. Thompson, published in the *Transactions of the American Electrochemical Society*, vol. 44, p. 359.

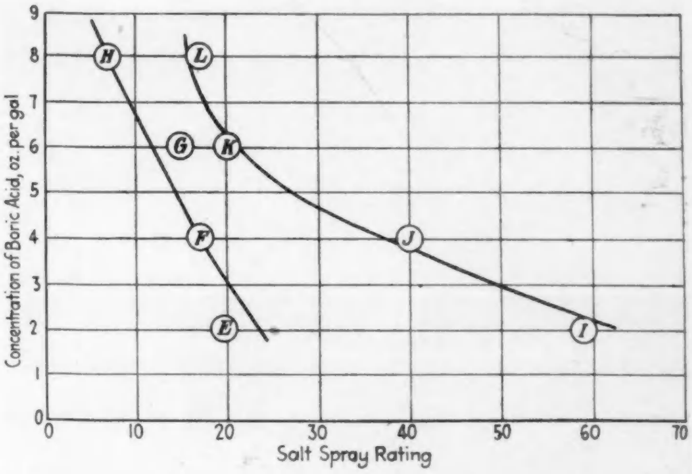


FIG. 6—EFFECT OF BORIC ACID IN NICKEL-PLATING SOLUTIONS ON THE SALT-SPRAY RATING

The Specimens Were Plated Under the Conditions Shown in Table 3, the Letters in the Circles Corresponding to Those in the First Column. The Results of This Experiment Show That the Lower the Concentration of Boric Acid in the Nickel-Plating Solution, the Higher Will Be the Salt-Spray Rating

Effect of Non-Metallic Inclusions in Steel

Other erratic results may be caused by defects in the metal being plated. Fig. 8 shows photomicrographs of spring steel plated with nickel, copper and nickel. This last or finish plating of nickel has been covered with a heavy copper plate in the laboratory to facilitate polishing, and so no attention should be given this outside "cover plate" of copper. The top view presents a fairly clean steel and the middle one a dirty steel showing a non-metallic inclusion sealed over with the first nickel-plating. The bottom view is a "close-up" of an exceptionally large hole, or non-metallic inclusion, which has

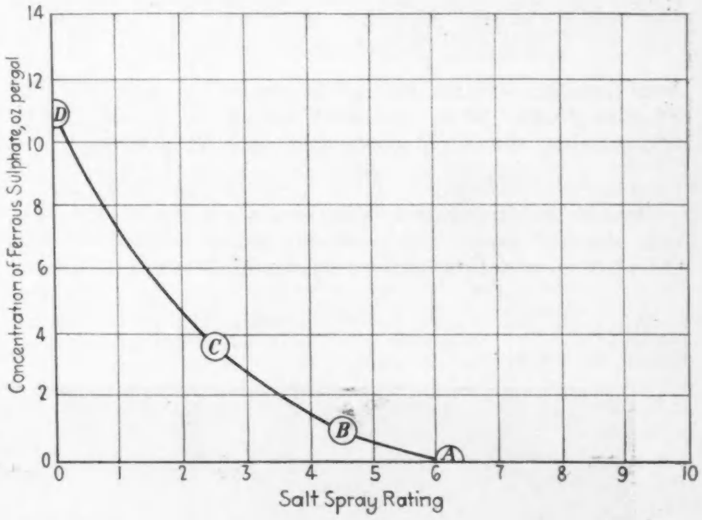


FIG. 7—EFFECT OF FERROUS SULPHATE IN THE NICKEL-PLATING SOLUTION ON THE SALT-SPRAY RATING

The Letters in the Circles Correspond to Those in the First Column of Table 6. From This Experiment the Conclusion Is Drawn That Nickel-Plating Solutions Should Be Free from Iron, as Even a Low Concentration of Iron Salts in a Nickel-Plating Solution Will Increase the Difficulty of Buffing the Plate

TABLE 6—EFFECT OF FERROUS SULPHATE IN A NICKEL-PLATING BATH ON THE SALT-SPRAY RATING

Point	Average Rating	Concentration of Iron, Oz. Per Gal.
A	6.3	0.00
B	4.5	0.93
C	2.5	3.72
D	0.0	11.10

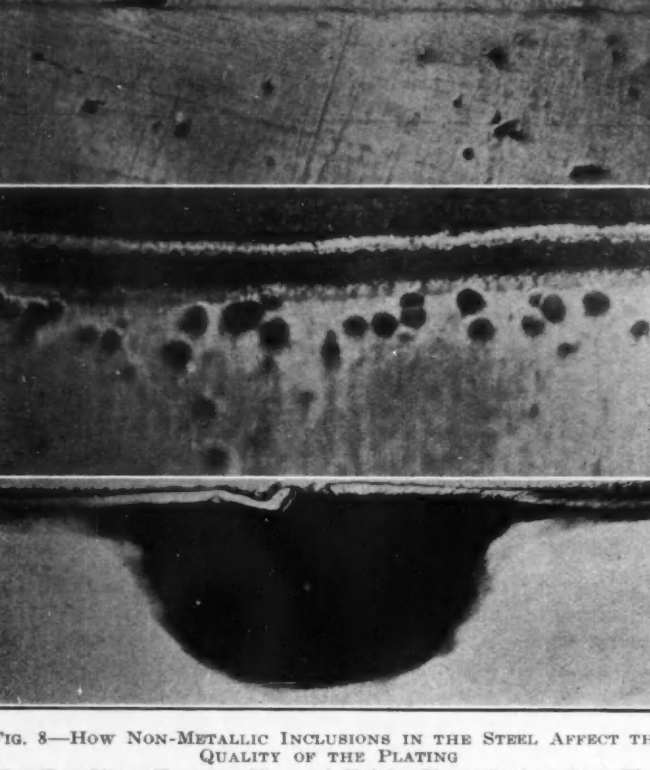


FIG. 8—HOW NON-METALLIC INCLUSIONS IN THE STEEL AFFECT THE QUALITY OF THE PLATING
The Top View Shows a Piece of Fairly Clean Spring Steel That Was Plated with Nickel, Copper, Nickel and a "Cover Plate" of Copper To Facilitate Polishing in the Laboratory. The Middle View Is of a Piece of Spring Steel That Was Given the Same Treatment, but in This Instance the First Plating of Nickel Sealed Over a Non-Metallic Inclusion. The Magnification in These Two Views Is 500 Diameters. The Bottom View Shows a Large Non-Metallic Inclusion That Was Nearly Sealed Over by the Plating. This Piece Was Tested in the Salt-Spray Box and after 3 Hr. of Exposure the Rust Was Plainly Discernible at a Distance of 3 or 4 Ft. The Magnification in This Case Is 300 Diameters

been nearly, though not quite, sealed by the plating. This particular piece had been tested in the salt-spray and reached the *VNR* stage after a 3-hr. exposure.

ADVANTAGES OF HIGH CURRENT-DENSITY

One of the important variables in plating is the current density used. There seems to be a more or less accepted view among platers that a high current-density will result in large crystalline structure. The reverse is true, as is illustrated by the photomicrographs of Fig. 9. These photomicrographs present the structure of electrolytic copper deposited at current densities of 12, 50, 100, 150 and 200 amp. per sq. ft. from an agitated bath containing copper sulphate and sulphuric acid.

These photomicrographs indicate that the higher the current density is, the finer grained will be the deposit. This is true for any solution, but different results may be secured with different solutions, since the micro-structure depends both on the current density and on the concentration of the ions of the metal being deposited. A fine structure may be produced from a solution of low ion-concentration at a low current-density or from a solution of high ion-concentration at a high current-density. The effect of varying the current-density is shown for only a single solution and plating condition, but the photomicrographs are a representative illustration of the general case[7].

The choice of which combination of conditions is to be used to produce a fine-grained deposit involves such questions as the reliability of operations, the operation and installation costs, as well as the quality of the deposits. The quantity of metal plated in a given time depends directly on the cathode current-density or, to put it somewhat differently, the thickness of the plating is proportional to the product of the current-density and the time. For a desired thickness of electrodeposit, the time required for plating varies inversely as the current-density. Hence, the output of work per day for plating-tanks of a fixed size varies directly as the current-density. For plating nickel and copper, it is common practice today to use current densities of from 3 to 10 amp. per sq. ft. of metal to be plated. Current densities of 35 to 100 amp. per sq. ft. are entirely feasible. With such current-densities the time required for plating, and therefore the size of the tanks and the floor space occupied in the plant, may be made one-tenth that required by the lower current-densities. Such high current-densities cut the time of plating in a given tank, for example, from 50 to 5 min. for the same thickness of plating, or to 10 min. for twice that thickness of plating. The corresponding reduction in the time of plating enables the use of labor-saving conveying-equipment, which needs to serve only a few tanks, whereas the installation costs would be prohibitive if 10 times the number of tanks were served. Further, deposits of nickel and copper having a total thickness of 0.001 in. are commercially practicable with the higher rate of electrodeposition.

[7] For a discussion of the basic theory, see the Crystalline Form of Electrodeposited Metals, by William Blum and H. S. Rawdon, published in the *Transactions of the American Electrochemical Society*, vol. 44, p. 397.

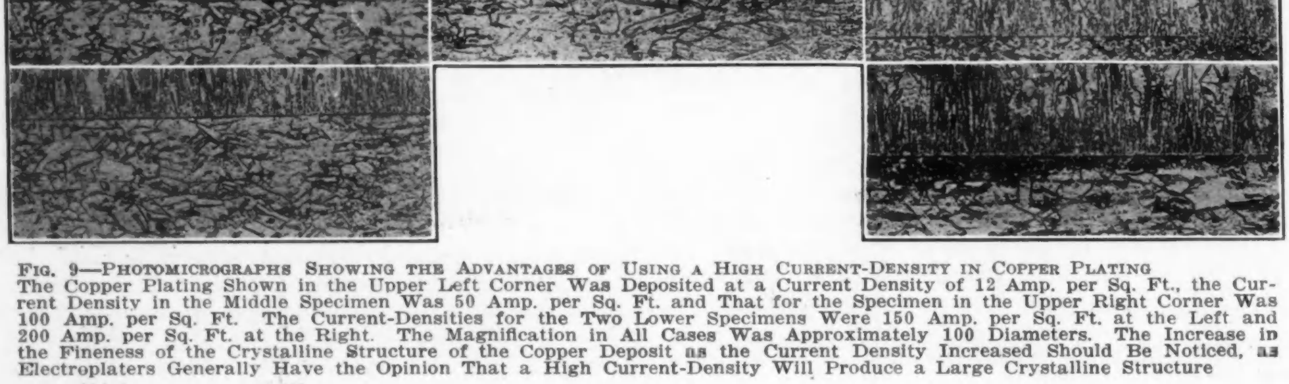


FIG. 9—PHOTOMICROGRAPHS SHOWING THE ADVANTAGES OF USING A HIGH CURRENT-DENSITY IN COPPER PLATING
The Copper Plating Shown in the Upper Left Corner Was Deposited at a Current Density of 12 Amp. per Sq. Ft., the Current Density in the Middle Specimen Was 50 Amp. per Sq. Ft. and That for the Specimen in the Upper Right Corner Was 100 Amp. per Sq. Ft. The Current-Densities for the Two Lower Specimens Were 150 Amp. per Sq. Ft. at the Left and 200 Amp. per Sq. Ft. at the Right. The Magnification in All Cases Was Approximately 100 Diameters. The Increase in the Fineness of the Crystalline Structure of the Copper Deposit as the Current Density Increased Should Be Noticed, as Electroplaters Generally Have the Opinion That a High Current-Density Will Produce a Large Crystalline Structure

These statements have as their basis not only laboratory experiments, but also the fact that plating at the higher rate has been proved feasible in four plants operating successfully for many months. Rigid technical control has been installed and with this and the developing of technical experience came reliability of operation. Quality of plating and reliability of operation were sought; not only were these found, but marked economies of operation also were produced.

The treatment given to plating has necessarily been sketchy, but may serve to indicate the desirability of placing the plating plant under close control. Plating in the industries today, with a few notable exceptions, has much the same status as heat-treatment had a few years ago, before the days of the common use of controlled conditions of temperature for heat-treatment and the chemical and micrographical analysis of steels. The Society has been highly instrumental in bringing the knowledge of the heat-treatment and the properties of steel, especially alloy steel, to the present status. The manufacturers of automobiles, automobile parts and accessories are now users of plating processes and plated materials. May I plead for similar interest and support in putting electroplating on a like footing?

ACKNOWLEDGMENTS

I wish to express my thanks in particular to Christian Girl, of the C. G. Spring Co., at whose instance the work here presented was performed, for permission to publish this material; to Herbert Jandus who conducted the salt-spray tests and to Prof. C. Upthegrove of the University of Michigan for the micrographical examinations.

SIX-WHEEL VEHICLES

TO anyone who has not followed closely recent developments in heavy road-transport, the number of six-wheel vehicles on view at the Commercial Motor Show at Olympia probably came as a surprise. Few would have prophesied 2 years ago, when only one example of the type was on exhibition, that this year no less than a dozen three-axle machines would be displayed. The new development affords a scope for much ingenuity in design, but at the same time is one that is full of traps for the unwary.

Broadly speaking, the six-wheel vehicle has attained its popularity in Great Britain by virtue of its ability to handle loads greater than can be taken by a steam wagon and a trailer at speeds approximating those associated with 5-ton gasoline motor trucks. The system is, of course, being applied to steam wagons also, but the probability is that the gasoline-driven six-wheel vehicle will become the most popular type. It is very interesting to observe the wide differences in the methods of tackling the problem adopted by English and French designers. On the Continent, the six-wheel vehicle is considered more as a four-wheel tractor drawing a two-wheel trailer. The English conception of the six-wheel vehicle, however, is a complete transportation outfit imposing a considerable proportion of its useful load on the rear axle of the power unit, to which the name of tractor hardly applies.

It is clear that a six-wheel vehicle can be built with a lower chassis-weight than a motor truck and a trailer of the same capacity, and the system can also be made to provide a greater proportion of the total weight as adhesion load on the driving wheels. While the reduction of individual axle weights is a matter of great importance in its bearing on road damage, nevertheless, on any but the very highest class of road, the weight on the driving wheels should be sufficient to prevent even incipient wheel-slip under adverse conditions. It seems reasonable to suppose that a rubber tire subject to horizontal forces of the same order of magnitude as the weight it is carrying will be more likely to disintegrate indifferent road-surfaces than one in which the vertical load is the dominating factor.

Much has yet to be learned on the subject of tires for these large vehicles, and the problem of transmitting 60 hp. or more through a pair of wheels is one that is by no means solved when a satisfactory transmission gear has been provided. Apart from the broader outlines of its design, the six-wheel vehicle provides a stimulating field of endeavor in coping with the difficulties involved in the steering and the braking of a vehicle of great weight and having certain maneuvering peculiarities of its own. Probably nothing has done more for the advancement of the power-operated brake than the introduction of the six-wheel vehicle. Time alone will show whether the articulated six-wheel vehicle with a dirigible rear-axle will be more popular than the more usual type in which the rear wheels merely trail behind the turntable axis.

The importance for English conditions of automatic means for detachment of the carrier has yet to be assessed, and we think that English builders are right in concentrating on the six-wheel vehicle as a complete unit, at any rate in the earlier stages of its development. It is in long-distance transport that the new machine is finding its widest sphere of employment at present, and for this work it is clear that a quickly detachable carrier is not of great importance. The advantages of keeping the motive-power unit continuously at work cannot be realized without employing two sets of drivers, while the most efficient use of the detachable carrier principle will, in many cases, involve considerable changes in works, warehouse and depot organization.

The future of the six-wheel passenger-vehicle is somewhat uncertain. It is not clear how the low-hung body work, which is becoming so essential on large-capacity omnibuses, can be fitted to the articulated six-wheel vehicle, and considerations of axle weight have not the same force in passenger work where the total loads are much less than in the freight-carrying vehicle.—*Automobile Engineer* (London).

SKEPTICISM

SKEPTICISM is a suspicion of error about facts, and to suspect error about facts is to share the enterprise of knowledge, in which facts are presupposed and error is possible. Skepticism is a form of belief. Dogma cannot be abandoned; it can only be revised in view of some more elementary dogma which it has not yet occurred to the skeptic to doubt; and he may be right in every point of his criticism, except in the single instance of fancying that his criticism is radical and that he is altogether a skeptic.—G. Santayana.

Some Suggestions for Builders and Users of Machine Tools

By THOMAS NADIN[1]

ANNUAL MEETING PAPER

MANY machine tools suffer from insufficient lubrication, both as regards the machine itself and in the means provided for lubricating the cutting tool. For slow-speed intermittent work it is satisfactory to lubricate a bearing through a small hole in the boss in which the shaft revolves; but this is not suitable for bearings of machines running constantly at medium speed. In stationary bearings a remedy is to be found in the use of a felt pad of liberal size on the under side of the bearing, kept in contact with it by a spring and properly protected from dirt. A better construction is the type of self-oiling bearing commonly used on electric motors and lineshafts, or better still a ball or roller bearing. Loose pulleys and similar bearings require roller bearings for slow and medium speeds, or single-row ball-bearings for higher speeds. These must be carefully designed for use with heavy mineral oil rather than cup grease.

Systems for supplying lubricant to the tool, although usually provided with pumps of sufficient size, frequently have guards and channels that are insufficient to take care of the splash and the return and a microscopic filter that soon becomes choked. On automatic machines these are sometimes found to be unusable after 2 weeks' service. This results in the spindle bearings, the slides and the screws becoming worn because of the presence of solid matter in the cutting oil. Tanks frequently serve as a storage space for chips. To obviate this, the tank should have two compartments, the first acting as a settling tank, from which the compound should flow over a weir into the second tank, in which the pump suction and the filter are located. The tank should be deep, be kept free from chips and swarf, have well sloped trays and channels and a filter of substantial construction of approximately 1 sq. ft. of filtering area well protected with gauze and should be easily accessible and removable. Flexible metallic hose is preferable to rubber, which becomes soft and useless after a short time. Defects could easily be overcome by the builders if purchasers and users would insist on having machines in which the troubles described are absent.

THE objects of this paper are to point out to the builders and the users of machine tools a number of extremely simple and obvious defects in many present-day production machine-tools and to offer some constructive suggestions for their elimination. The defects, however, are so simple that an analysis of the troubles automatically suggests the cure; they are deemed worthy of attention because of the expense required to keep the machines on which they are present in operation and also because of the lost time and consequent interference with production that repairing them entails.

The points to which attention is directed may be classified under two heads:

(1) More thorough and more automatic lubrication
(2) Better cutting-lubricant systems

Taking up the first point, we all are familiar with the bearing that consists of a hole drilled and reamed in a cast-iron boss in which a shaft revolves. For lubricating this bearing, a small hole is often drilled, which is sometimes provided with a cover. Such a bearing, if properly proportioned is, of course suitable for low-speed intermittent work, but to employ such a bearing for constant running at medium speeds is obviously wrong and must result in either a large expenditure of time and oil, or a frequent renewal of the shaft or the bearing surface. Under present-day conditions, it is very difficult to find operators that will spend the time necessary to keep the lubrication satisfactory; so it usually means that a greater amount of money and time are spent in renewal and repair. This kind of bearing is commonly used in loose pulleys and is probably one of the biggest wasters of time in a factory. It is used in many positions on a great number of machines.

A remedy for such a trouble in stationary bearings would be the use of a felt pad of liberal size on the lower side of the bearing. The pad may be cylindrical in form and kept in contact with the shaft by a spring. If the bearing has an open end, it should be protected by an oil-tight cover to exclude dust and retain the oil and means should be provided for returning the oil to the reservoir in which the felt pad is located. The other end should be provided with a cover closely fitting the shaft and means provided for returning the used oil to the central reservoir. Such a scheme is in common use on small motors and works very satisfactorily. With this construction, it would be necessary to oil the bearing only once a week instead of daily.

A still better construction would be to make use of a self-oiling bearing similar to those used on electric motors and lineshafts, or to use a roller bearing, or a ball bearing. In this case also, the retention of the lubricant and the exclusion of dirt are of the greatest importance. Such bearings do not require attention more than once a month for ring-oiling bearings, or once every six months for ball or roller bearings.

USE OF ROLLER BEARINGS

For loose pulleys and similar running bearings, the problem requires different treatment to obtain a satisfactory solution, and use should be made of roller bearings for slow and medium speeds, or single-row ball-bearings for higher speeds. Such bearings, however, require careful design to give satisfactory service. By careful design I do not mean expensive production methods, but rather the incorporation into them of correct principles. For a ball or a roller bearing to work properly, it is necessary to exclude dirt and water or cutting compound absolutely and to retain a certain amount of lubricant, preferably heavy mineral oil and not cup grease, which is liable to dry out. If such conditions are fulfilled, loose pulleys will run for 6 months with one filling with lubricant and without wear or expense for attention of any kind. If we assume that an ordinary loose pulley or clutch is oiled every other day

[1] General superintendent, Rolls-Royce of America, Inc., Springfield, Mass.

for 300 working days per year, and the average time of oiling is only 3 min., we shall have 450 min. per year expended, without counting the time of repairs or the cost of the oil. The saving of this time alone would pay a good dividend on the extra cost of a ball or a roller bearing.

The question of the exclusion of dirt, water and the like from ball or roller bearings is of supreme importance and ranks equally with the retention of the lubricant. These points cannot be too carefully attended to and will amply repay such care as may be given them. Most of the ball-bearing makers publish a collection of sectional elevations showing the application of their bearings to various machines, but for some reason a large number of ball bearings are used every year without the simple and inexpensive features for excluding dirt and moisture and retaining oil that are so necessary for success.

The Cutting-Lubricant System

The second point that I should like to discuss deals with the cutting compound, or oiling system for machine tools, and is perhaps simpler of solution than the first. It is just as important from the point of view of production. Most modern machines are provided with a more or less complete system for storing a supply of compound or oil, a pump and piping for delivering it to the point of contact between the work and the tool and means for returning the compound to the storage tank. The pumps are usually of sufficient size to give a proper stream, but the guards and channels, more often than not, are insufficient to take care of the splash and the return. The filter is often of microscopic size and very soon becomes choked. The operator cleans it once or twice after the lubricant supply has failed and then, in desperation, removes or pierces the filtering medium. From that time on, the destruction of the pump, control cocks on the pipes and any joints that are required to move proceeds rapidly by the cutting action of the chips carried in the compound or oil. On automatic machines, working constantly, it has been common to find a pump unusable from this cause after 2 weeks. The destruction in many instances, unfortunately, goes much farther than this.

In machines using oil and improperly guarded, we find the spindle bearings, the slides and the screws all badly worn, because of the presence of so much solid matter in the cutting oil. Guards for the splash and the slides are for the most part inadequate, and it seems almost a matter of course to bring in a sheet-metal worker and have him fit some clumsy, unsightly and troublesome splash-guards as soon as a machine has been installed. The channels for catching and returning the lubricant are often very poor and sometimes incomplete, requiring the use of putty or rags to insure the compound's going the right way. Drilling machines and some milling machines are particular offenders in this respect.

The Construction of Tanks

Tanks often have the appearance of being the result of an accident rather than of careful design and in many cases serve as a storage space for chips. From the designers' and the builders' points of view, the remedy is comparatively simple. The tank itself should be of liberal dimensions and preferably be divided into two sections. The first section should receive the compound from the channels or the trays of the machine and should act as a settling tank. The compound should flow out of the first tank over a weir into the second tank, in which the pump suction and the filter are located. The tank should be deep, with a small cross-section, rather than shallow with a large dust-collecting and evaporating surface exposed to the shop. Chips and swarf should be carefully kept out of the compound tank, and the trays and the channels should be well sloped to drain the compound back.

The filter on the pump suction should be substantial in construction, with the gauze well protected, and have a filtering area of approximately 1 sq. ft. It should be easily accessible and removable and should be placed with the main area of the gauze horizontal with the suction above, so that chips and dirt will fall away from it, by gravity, to the bottom of the tank.

Guards of substantial construction and of ample size for protecting the slides, the bearings and the screws of the machines should be fitted. Other guards are also required to control the splash from the rotating work or tools. They should all be of sufficient size to deal with the maximum flow at the maximum working speed without allowing the compound to reach the operator or the floor. The same remarks apply to return channels and pipes. Rubber connections should not be used for compound, as they invariably become soft and useless after a short time. Flexible metallic hose of adequate size, with sound joints, should be used instead.

It is hoped these suggestions made for overcoming some of the troubles may be of interest to some builders and suppliers of machines. The purchasers and the users of tools in which these defects are present can have the faults corrected if they will demand machines in which the troubles are absent and refuse to order machines in which they have not been eliminated. The use of machines equipped in accordance with these suggestions should result in a reduction in the labor costs for attention and repairs, cleaner machines, a reduction in accidents and the lost time involved by reducing the period of the hazard and a corresponding increase in production.

TRUTH AND PROGRESS

THE discouragement we may feel in science does not come from failure; it comes from a false conception of what would be success. What matters is that science should be integrated with art, and that the arts should substitute the dominion of man over circumstances, so far as this is possible, for the dominion of chance.

The happy results and fertility of an assumption do not prove it true literally but only prove it to be suitable, to be worth cultivating as an art and repeating as a good myth. The axioms of art must correspond *somehow* to truth, but the correspondence may be very loose and partial. Moreover, the circumstance that even this symbolic rightness is vouched for only by an experience that would be false in all its records if this assumption should prove to be false, robs such experimental data of practically all of their logical force.—G. Santayana.

New Quantitative Method of Measuring the Riding Comfort of Automobiles

By F. H. Norton[1] *Illustrated with* Drawings and Photograph

A PASSENGER riding in an automobile experiences a continuous series of impulses that primarily originate from the irregularities in the road surface. If these impulses are small the passenger feels no discomfort, and at times a certain degree of motion is decidedly pleasurable; but if they become too large or too frequent a feeling of discomfort is experienced. It has been the aim of the automotive engineer to design the tires and the spring-suspension so that the passenger will receive the minimum of road shock. How well he has done it can be strikingly brought out by riding rapidly in a springless, steel-tired wagon over a familiar road. However, room for still further improvement in the riding quality of automobiles exists; but before the subject can be considered systematically we must have some quantitative measure of that elusive term, riding quality.

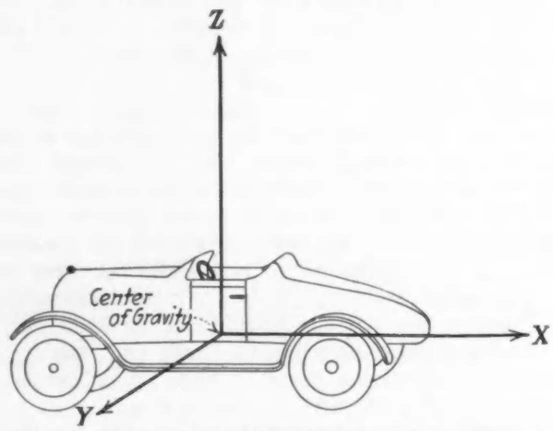


Fig. 1—Sketch Showing Relation between the Three Axes Used To Determine the Accelerations Acting on a Passenger in an Automobile
The Acceleration Acting at the Center of Gravity of an Automobile Is Expressed by Six Measurements, Three of Which Are along the Three Axes Shown While the Other Three Are around These Axes

Not long ago the controllability of airplanes was measured only by the opinion formed by the test pilot, which gave at best only a rough qualitative measure, and at worst very misleading conclusions. Recently recording instruments have been developed which are capable of giving quantitative measures of these factors, thereby placing the design of combat planes on a more scientific basis. The question at once arises as to the possibility of designing an instrument to record the riding qualities of an automobile.

Accelerations Acting on a Passenger

First let us consider a passenger riding on the seat of an automobile. He is continually subjected to displacements that may be differentiated into velocities and accelerations, both linear and angular. It is a well-known fact that a human being cannot feel displacement or velocities; that is, a person blindfolded could not tell at what uniform velocity he was being carried. On the other hand everyone can feel changes in velocity or accelerations. Acceleration then is the principal if not the sole physical quantity causing riding discomfort and is the quantity that must be measured.

In general there are six independent measurements necessary to determine completely the accelerations acting on a passenger. Using the nomenclature common in aeronautics with the axes placed as shown in Fig. 1, we can express the acceleration acting, for example at the center of gravity of the automobile, by the following six values:

du/dt—longitudinal, along the path of the car or the X axis
dv/dt—lateral, across the path of the car or along the Y axis
dw/dt—vertical or along the Z axis
dp/dt—roll, about the X axis
dq/dt—pitch, about the Y axis
dr/dt—yaw or skid, about the Z axis

where

p = the component of the angular velocity about the X axis
q = the component of the angular velocity about the Y axis
r = the component of the angular velocity about the Z axis
u = the component of the velocity along the X axis
v = the component of the velocity along the Y axis
w = the component of the velocity along the Z axis

Several of these quantities are fortunately so small that they can, for the present at least, be neglected, leaving as the important ones only dw/dt and dq/dt. It must not be concluded that the others may be entirely disregarded, for in certain unusual circumstances they may assume considerable proportions. Under the majority of conditions the vertical accelerations are more important than the pitching, and for that matter pitch can be measured by two simultaneous readings of the vertical acceleration at two stations along the X axis. What is needed then is an instrument to continuously record the vertical acceleration at a point or points in the automobile.

Design of the Accelerometer

Considering now the design of the instrument itself, there must be essentially a vertically deflecting spring with a weight on the end and a means for recording the motion of the weight. Perhaps the first recording accelerometer used was the R. A. F. instrument[2] constructed for airplane use. This instrument while satisfactory for its purpose does not have a high enough period or damping to make it exactly suited for automobile use.

A more modern type of instrument is the accelerometer of the National Advisory Committee for Aero-

[1] Jun. S.A.E.—Massachusetts Institute of Technology, Cambridge, Mass.
[2] See British Advisory Committee for Aeronautics Report and Memorandum No. 476.

nautics originally suggested by Prof. E. P. Warner and later developed by me[2]. Here the spring is a steel cantilever with an adjustable damping device on the free end. This instrument has a high natural period, critical damping and gives a large and accurate record. It has the disadvantage of large weight and bulk and of giving a rather short record for automobile use. Therefore, a new instrument was constructed of the same general type but especially suitable for automobile work.

The cross-section of this instrument shown in Fig. 2 indicates the essential parts. The flat cantilever spring *a* is rigidly fastened at one end to the spring base *b*. Accelerations acting at right angles to the plane of the spring will move the free end slightly. This motion is transmitted by the hardened steel stylus *c* to the platform of the rocking mirror *d*, where it is converted to a relatively large rotation. As it is necessary to damp[3] critically the motions of the spring, a vane, *e*, is attached to its free end and this moves in, but does not touch, the oil-filled dashpot *f*.

Because of the high natural frequency required in the spring for accurate recording[3], the mass and friction of the recording parts must be a minimum. Optical methods are the only ones that fulfill the requirements. In this instrument light starts at *g*, passes through the lens *h*, is reflected from the mirror *d* and, passing through the same lens a second time, is focused on the film *i*. Thus a slight rotation of the mirror *d* causes the image to move across the film. A vertical slit *j* is placed in front of the film to limit the width of the image. The magnification obtained can be varied by changing the relative position of the stylus and the mirror staff, but a multiplication of 200 times is ordinarily used.

The film is driven at a constant speed of 7 in. per min., which is found most satisfactory for automobile work. The motor, *k*, is specially constructed for slow and constant speed, but the details of its construction need not be described here. The film is stored and taken up on the spools *l*. Enough film is available for a record of ½ hr.

The sensitivity of the instrument can be varied by sliding the sensitivity weight *m* along the spring. The battery is connected to the instrument through the bayonet plug *n*. To locate any particular event on the film, the light *o* is provided and is connected to a button so that a vertical line can be made on the film at any desired point. The zero mirror *p* is used to place a fixed line on the film for reference.

The complete instrument, shown in Fig. 3, is so compact that it can be carried in the coat pocket. The current taken by the lights and the motor is only 0.3 amp. at 6 volts and can be supplied by flashlight batteries.

TABLE 1—EFFECT OF THE POSITION AND MOUNTING OF THE ACCELEROMETER ON THE READINGS[4]

Type of Mounting	First Maxima	Second Maxima
On the Carpet on the Floor in the Front of the Car	1.7	1.4
On the Carpet on the Floor in the Rear of the Car	1.2	1.8
Set on Front Cushion	1.4	1.5
Set on Rear Cushion	1.3	2.0
Held in Passenger's Lap in Front Seat	1.4	1.2
Held in Passenger's Lap in Rear Seat	1.1	1.6

[4] Readings are in terms of *g*.

[3] See National Advisory Committee for Aeronautics Report No. 100.

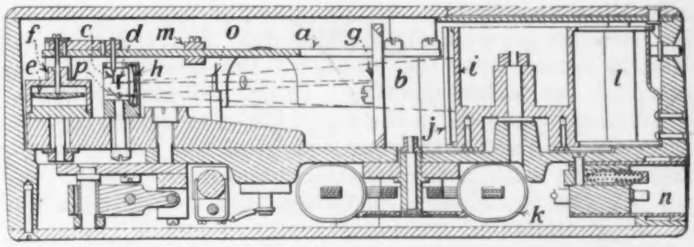


FIG. 2—CROSS-SECTION OF THE ACCELEROMETER DEVELOPED TO MEASURE AUTOMOBILE ACCELERATIONS

This Instrument Was Based on the Accelerometer That Was Developed by the Author for Aircraft Work. The Original Design Was Characterized by a High Natural Period, Critical Damping and the Giving of a Large and Accurate Record. However Its Disadvantages of Large Weight and Bulk and of Giving a Short Record for Automobile Work Necessitated the Construction of a New Instrument of the Same General Type, in Which a Flat Cantilever Steel Spring *a* with an Adjustable Damping Device *e* on the Free End Was Used, That Was Especially Suitable for Automobile Work

ACCURACY OF READINGS

It is unnecessary to go into a discussion of the precision obtained by this type of instrument here. With proper care, however, the readings should be good to 0.05 *g* up to a frequency of 30 vibrations per sec.

The exact position and mounting of the instrument in the automobile is a matter of some importance. To show the results obtained by different mountings, car No. 1, referred to later, was run over an artificial bump, composed of a board 7 in. wide and 1⅜ in. thick, at 17 m.p.h. The records all showed two maxima, one due to the front wheels and the other due to the rear. The value of these maxima in terms of *g* is given in Table 1.

The records taken with the instrument on the floor are unsatisfactory because of numerous small tremors due to the engine. It was difficult to pick out the significant peaks. The records on the cushion were better, but gave high maximum and low minimum values which can only be due to the instrument bouncing on the cushion springs. When the instrument is held firmly in the lap a smooth and satisfactory record is obtained as all the small tremors are damped out. This latter position seems the only fair one as the acceleration recorded is the acceleration the passenger experiences under the actual conditions of riding.

As it is difficult to specify a standard passenger, it may be better to place a given weight on the seat and mount the accelerometer on it with a sponge rubber block. If strictly comparable tests are to be made this procedure would probably be necessary.

It is not the intention to attempt the systematic study

FIG. 3—EXTERIOR VIEW OF THE ACCELEROMETER

The Instrument as Finally Developed Was Compact Enough To Be Carried in the Coat Pocket. Only 0.3 Amp. at 6 Volts Was Required for the Lights and This Current Could Be Supplied by Flashlight Batteries

of riding quality here, but to give the usual values of acceleration occurring in vehicles over different surfaces and to demonstrate the ability of the accelerometer to measure the desired quantity. In the following tests the instrument was held in the lap of the passenger who was the only occupant of the rear seat. Car No. 1 was a very light sedan with a tire-inflation pressure of 60 lb. per sq. in. Car No. 2 was a medium-weight sedan with tires at about the same pressure.

No definite period is shown in the records, but in many cases a damped oscillation can be observed with a frequency of the rear springs. It is also noticeable that at high road-speeds the frequency of the average vibration increased as should be expected.

In Table 2 are listed the important data from each run made on the two cars tested, together with a few from other vehicles. The values given for the accelerations are all in terms of g.

TABLE 2—DATA ON THE VERTICAL ACCELERATION OF AUTOMOBILES AND OTHER VEHICLES

Vehicle	Condition of Test	Speed, M. P. H.	Average Maximum Acceleration[5]	Maximum Acceleration[5]	Average Minimum Acceleration[5]	Minimum Acceleration[5]
Car No. 1	Very Smooth New Macadam	10	1.15	1.25	0.80	0.75
		20	1.15	1.30	0.75	0.70
		30	1.20	1.35	0.75	0.55
	Fair Macadam	10	1.25	1.40	0.80	0.60
		20	1.25	1.40	0.80	0.55
		30	1.30	1.80	0.75	0.60
	Rough Worn and Patched Macadam	10	1.35	1.80	0.75	0.60
		20	1.35	1.75	0.80	0.60
		30	1.40	1.70	0.70	0.45
	Very Rough Worn Macadam with Pot Holes	10	1.50	2.25	0.65	0.00
		20	1.30	1.60	0.75	0.40
		30	1.55	2.30	0.65	0.00
	Worn Cobblestone Paving	10	1.45	2.10	0.75	0.25
		20	1.25	1.75	0.80	0.40
		30	1.55	2.45	0.60	0.00
	Sharp Draw Rise on Wooden Bridge	20	......	1.60	......	0.40
Car No. 2	Fair Macadam	10	1.20	1.50	0.75	0.70
		30	1.30	1.70	0.70	0.45
	Rough Worn and Patched Macadam	10	1.20	1.50	0.75	0.55
		30	1.45	2.25	0.60	0.00
	Very Smooth New Macadam	20	1.10	1.25	0.80	0.70
	Sharp Draw Rise on Wooden Bridge	20	......	1.70	......	0.30
Railroad Coach	Average Track with Accelerometer Located at the Center of the Car	35	1.10	1.20	0.90	0.75
Trolley Car		20	1.10	1.30	0.90	0.70
Subway Train		30	1.10	1.15	0.90	0.85
Airplane[6]	Severe Porpoise Landing	50	......	5.20	......	......
	Severe Pancake Landing	38	......	4.90	......	......
	Average Three-Point Landing	42	......	2.50	......	......
	Taxying on a Fairly Smooth Field	30	......	2.50	......	......
	Violent Stunts	40 to 100	......	4.20	......	......

[5]Values given are in terms of g.
[6]See National Advisory Committee for Aeronautics Report No. 99.

The average maximum accelerations were determined by an inspection of the prominent peaks and is to some extent a matter of judgment although it may be seen that in any given record the majority of the peaks are of nearly the same height. The maximum values are very determinate.

The runs made over the same road at different speeds are not strictly comparable as it was impossible to drive in exactly the same place each time even though an attempt was made to do so. The same may be said to an even greater degree when comparing the results obtained from the two cars. However, the data shows some interesting facts that will merely be mentioned.

(1) The greatest vertical acceleration encountered was 2.45 g which felt like a very severe jolt
(2) The lowest vertical acceleration encountered was 0.00 g or that of a freely falling body. In this case the passenger left the seat
(3) The effect of the car speed on vertical acceleration depends on the road; on a smooth road there is little difference between 10 and 30 m.p.h., but on rough roads the vertical acceleration is less at 20 m.p.h. than at 10 or 30 m.p.h.
(4) The heavier car at high speeds and on the rougher roads showed greater accelerations than the lighter one, while at low speed and on smooth roads the reverse was true
(5) Railroad, trolley and subway cars showed vertical accelerations of about the same magnitude as automobiles driven on the smoothest roads
(6) The vertical accelerations experienced in airplanes are considerably greater than those encountered in automobiles

Factors to be Considered in a Further Study

In continuing the study of riding comfort, the following is suggested as a method of approach in answering some of the many questions that remain: In the first place some laboratory tests should be made to determine some of the psychological and physiological effects of riding shocks. For example, does the rate of change of acceleration, the duration of the acceleration or a series of equal shocks affect the riding comfort? For a given intensity do some components of acceleration feel more uncomfortable than others? What effect does noise and the consciousness of displacement by sight have on the comfort of the passenger?

Secondly, the support of the passenger in the car should be carefully considered. What share does the seat, the back, the floor and the sides contribute to the forces imparted to the passenger? What is the difference between rough and smooth seat-covers? Would a spring mounting of the seat-back and the foot-rest make easier riding? Would a belt like an airplane safety-belt make the passenger more comfortable?

Thirdly, the spring-suspension of the car should be studied to answer many important questions. What is the effect on the riding qualities of the wheelbase length, the unsprung weight, the types of tire, the spring period and deflection or snubbers and shock-absorbers? What is the best ratio for the periods of the front and rear springs?

And last, the effect produced by various kinds of road irregularity is important not only from the standpoint of better roads, but also to aid in designing more comfortable cars. What is the effect of the car-speed on a given bump? What is the effect of the type of bump, a series of repeated bumps, such as cobblestones, or deep ruts? To obtain consistent results a smooth track with standardized bumps must be used.

It is felt that the recording accelerometer carefully used will give quantitative measures of riding quality. No attempt has been made here to study riding quality systematically, but some examples are shown which indicate the general magnitude of the accelerations encountered on the road. If further tests confirm the conclusions already reached, the automotive engineer should be able to place the design of automobiles for riding comfort on a scientific basis rather than on the more or less cut-and-try basis that now prevails.

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Fundamental Improvements in Manifold Design

By A. M. Dean[1], J. W. Swan[2] and C. A. Kirkham[3]

Annual Meeting Paper *Illustrated with* Charts and Drawings

MANIFOLDS that have been designed as if they were intended to handle a fixed gas and that depend upon the application of excessive heat have not produced satisfactory results. Although heat in a limited amount aids vaporization, it is an agent that must be used with caution. As present-day fuels are composed of volatile constituents blended with the heavier ends, only a part at best can be vaporized and manifolds should be designed so that they will distribute wet mixtures or fog, instead of dry gases, uniformly at varying engine speeds and varying throttle positions. The four elements in the mixture furnished to the engine are air, water vapor, gasoline vapor and liquid particles of gasoline or fog. Liquid particles of considerable volume can be held in the airstream without depositing if the velocity is kept relatively high. But when rapid reversals in the direction of mixture-flow occurs, as in the manifold of a multi-cylinder engine, the particles separate out by gravity and deposit.

An efficient manifold must not only conduct the fuel mixture but must distribute it uniformly in the same condition as that in which it left the carbureter. Manifolds that are designed for maximum power sacrifice performance at low speeds so that the tendency recently has been to reduce the size of the intake and increase the speed of the mixture to obtain more satisfactory low-speed performance. Efficient operation of a manifold is indicated by increased torque, increased acceleration, economy and ease of starting the engine, while the secondary results to be noted are uniform firing, even when starting cold, and a consequent reduction in the dilution of crankcase oil, lessened vibration and lessened carbonization. Although many engineers have assumed that distribution is equal when the power developed by the several cylinders is equal, this assumption may be in error; the air-to-fuel ratio may vary considerably, yet the power developed remain the same. The most accurate means of determining the distribution is an analysis of samples of exhaust gas taken simultaneously from the individual cylinders. To obtain equal distribution the fuel can best be supplied to the cylinders as a fog and this can be done without the use of heat. An analysis of conventional types of manifold construction shows that almost invariably the lighter fuel-fractions are furnished to certain cylinders and the heavy ends to others.

In the Swan method of distribution the forces, due to the suction of the several cylinders, acting upon the carbureter are all equalized at the top of the riser or metering point of the systems. The result is equal flow in each branch. Also successive flows are always in a different direction from this metering point to minimize inertia effects.

The manifold is a straight-line type of square or rectangular section and the turns are abrupt and at substantially right angles. The flat floor of the square section provides the maximum area for exposing the liquid fuel to the airstream. Among the advantages claimed for a manifold of this type are (*a*) straight-line manifold (*b*) the holding of the atomized fuel from the carbureter in an atomized condition in the airstream to the cylinders and (*c*) low first cost, which in many cases is appreciably less than in manifolds of conventional type. Although heat is not necessary to realize equal distribution, a certain amount is required to offset the rapid reduction of temperature above the throttle-valve at closed-throttle positions, which normally would cause the temperature to drop below the dew-point. In the Swan manifold the application of a fixed amount of heat of the maximum intensity is entirely automatic in its action because of the difference in the velocity of the mixture at open and part-throttle positions. Curves of brake horsepower, torque and fuel consumption are given to show the comparative operation at various loads of Swan manifolds and those of the conventional type.

IN recent years much time and thought have been expended upon the design of intake-manifolds for motor-car engines. This is clearly evidenced by the wide varieties of manifold seen on our cars of today. That the results obtained from such manifolds are far from satisfactory is shown by the radical changes in manifold design occurring from year to year in engines produced by the same builders.

Following the precedent set by early builders, manifolds evidently have been designed as if they were to handle a fixed gas, and their proportions determined by the laws governing the flow of gases or air. These manifolds did not achieve the desired results, but, as it was found that heat materially improved their performance, heat was believed to be the solution of the problem. Since in any development it becomes necessary to go to extremes to determine definite practical limits, this has been done in the application of heat.

The result has been the development of manifolds using excessive heat, but this again has proved detrimental. Heat in a limited amount, properly applied, is an advantage in that it aids vaporization, but it is an agent that must be used with caution. Judging from the results obtained, it is evident that designers have based their calculations upon a wrong assumption of the media they must handle. Present-day gasoline fuels are composite, made up of varying portions of the lighter or more volatile constituents blended with the heavier ends. A small percentage, comprising the very lightest portions, will vaporize even at temperatures approaching 0 deg. fahr., while the heaviest portions will not vaporize with the available heat of the engine.

Since we can at best vaporize only a part of the fuel, it is evident that the manifold must be designed to distribute uniformly wet mixtures or fog instead of dry gases at varying engine speeds and varying throttle positions. It might be well to state that the term "vapor" is used to define a liquid that has been transformed into a gas, while the terms "wet mixtures" and "fog" are

[1] M.S.A.E.—Engineer, Swan Carburetor Co., Cleveland.
[2] Vice-President and consulting engineer, Swan Carburetor Co., Cleveland.
[3] Chief engineer, Swan Carburetor Co., Cleveland.

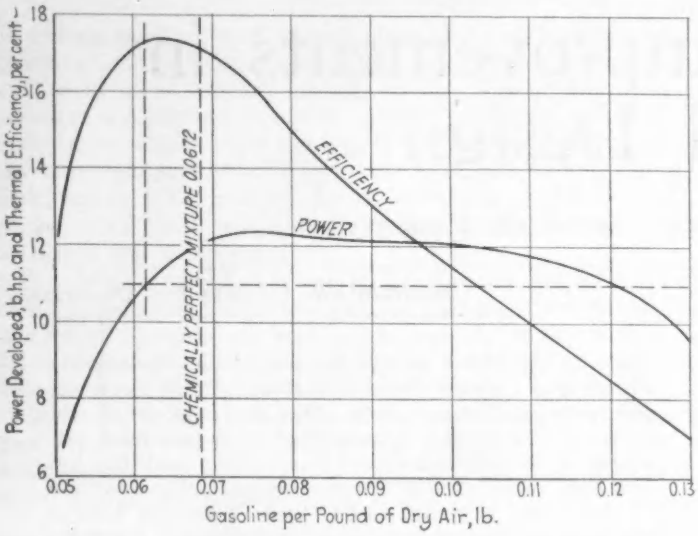

FIG. 1—CHART SHOWING THE THERMAL EFFIENCY AND THE POWER DEVELOPED AT A SPEED OF 1000 R.P.M. WITH DIFFERENT MIXTURE-RATIOS

It Should Be Noted in Connection with These Curves That While the Same Power Can Be Developed with a Mixture-Ratio of 8 to 1 as with a 16 to 1 Mixture-Ratio, the Thermal Efficiencies Are Very Different

used to define a highly atomized liquid, in which the particles may be carried in suspension in the air at some definite velocity. Air carries with it varying amounts of water in vapor form that are expressed in terms of humidity. We have therefore four elements to deal with in the mixture furnished to the engine:

(1) Air
(2) Water vapor
(3) Gasoline vapor
(4) Gasoline liquid particles or fog

Air, depending upon its temperature, will carry varying amounts of water vapor up to its saturation-point. If an excess of moisture is added or the temperature is

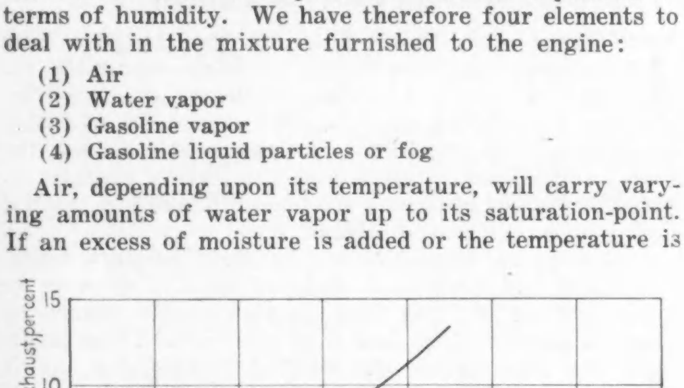

FIG. 2—CHARTS SHOWING THE PROPORTION OF FUEL WASTED AND THE COMPOSITION OF THE EXHAUST GAS WITH VARIOUS AIR-FUEL MIXTURES

In the Upper Chart Will Be Seen the Relationship between the Percentage of Carbon Monoxide in the Exhaust and the Percentage of Fuel Wasted Which Is That 1 Per Cent of Carbon Monoxide Represents a Waste of Approximately 4 Per Cent of Fuel. The Lower Chart Shows How the Percentages of Carbon Monoxide, Carbon Dioxide and Oxygen in the Exhaust Gas Vary for Different Air-Fuel Ratios

rapidly lowered, water will precipitate out, as fog or rain. This is a condition, well demonstrated by Nature, that occurs in a manifold handling mixtures of the elements we have defined, for the actions of liquid fuel and moisture are similar. Liquid particles of considerable volume can be held in the airstream without depositing, if the velocity is kept relatively high. Since rapid reversals in direction of the mixture flow occur in the manifolds of multi-cylinder engines, it follows that there are corresponding periods of rest when such liquid particles acted upon by gravity will separate out and deposit. These are the conditions we must meet in manifolding.

Let us first define a manifold. In the simplest form of single-cylinder engine the carbureter may be attached directly to the cylinder and no manifold is necessary. But when a multi-cylinder engine is supplied with fuel from a single carbureter, a system of passages, either external or internal to the cylinder, must be devised to conduct the fuel mixture to the respective cylinders. Whatever form this system of passages may take is called a manifold.

To be efficient the manifold must do more than merely conduct the fuel mixture. It must distribute the mixture uniformly and must maintain the mixture in the same condition as that in which it left the carbureter. In other words, this distribution to the various cylinders must be equal not only as regards the quantity of the mixture but, what is more important, equal as regards the quality of the mixture.

The construction of a manifold is apparently simple and evidently is so considered by many engineers, but the functions of a manifold and its influence on distribution have not been fully realized. Many manifolds apparently have been designed with maximum power as the primary consideration. Maximum power requires correspondingly large areas and free passages in the manifold and is usually attained only at a sacrifice of performance at low speeds. There has been a noticeable tendency during the last year for designers to reduce the size of intake-manifolds and increase the velocities of the mixtures to obtain more satisfactory low-speed performance. This had to be done with a full knowledge of the sacrifice of top-end performance of the engine.

WHAT THE CARBURETER AND THE MANIFOLD SHOULD DO

The carbureter should furnish a mixture of air and finely atomized fuel in the proportions required by the engine. This, broadly, is its entire function and is performed automatically by carbureters of the best design. One condition, however, that cannot be controlled automatically by simple means is the change of altitude and of the varying air-pressures.

An intake-manifold, although it cannot correct the unfavorable characteristics of the carbureter, should distribute uniformly to the cylinders fuel in equal quantities and in the same condition; that is, having the same ratio of light and heavy fuel-fractions as that delivered to the manifold by the carbureter. If we can realize this condition we shall have obtained an efficient manifold, as evidenced by

(1) Increased torque, particularly at low engine-speeds, due to uniform power development
(2) Increased acceleration due to uniformly rapid-burning mixture in each cylinder
(3) Economy; since the carbureter may be set at the point of best economy without the necessity for favoring certain cylinders
(4) Ease of starting; since the tendency to "load" in certain cylinders is avoided

Equal distribution, when accomplished, realizes some secondary results nearly equal in value to the first.

(1) Supplying a uniform mixture to each cylinder
(2) Lessened vibration
(3) Lessened carbonization
(4) Fixed ignition

Supplying a uniform mixture to each cylinder makes possible uniform firing in each cylinder even when starting cold, and consequently reduces the dilution of the crankcase oil by the unburned fuel-fractions passing the pistons. This dilution of crankcase lubricating oil is one of the serious problems of the automobile owner and builder. The dilution is very deceptive in its results, since by reducing the lubricating value of the oil it induces rapid wear without visible indication to the driver. The oil level in the crankcase is retained, as is shown by the gage, but without indicating the condition of the oil. Dilution, while going on continually in all engines, is rapidly increased by cold starting and irregular running when cold, with the consequent tendency of the driver to enrich the mixture unduly at these times. Equal distribution of a proper mixture will reduce this dilution to the minimum determined by the mechanical condition of the engine.

It has been demonstrated that periods of vibration in engines are largely influenced by fuel distribution and that severe periods can often be reduced by a change in the carbureter adjustment and by realizing a better fuel-mixture condition at the particular speed. Uniform distribution reduces the vibration to that produced by mechanical unbalance or torsional vibrations in the engine.

A uniform quick-burning mixture in all cylinders insures clean burning of the fuel with the minimum of carbon deposit. A cylinder developing its full proportion of power has but little tendency to over-oil; consequently carbonization from this source is minimized.

Since a uniform mixture is delivered to each cylinder, uniform combustion is assured and the spark can be set at its most effective position without the necessity for favoring the most starved cylinders of the group. This reduces spark manipulation to the minimum and makes more effective the use of a fixed spark-position for taxicab and truck use.

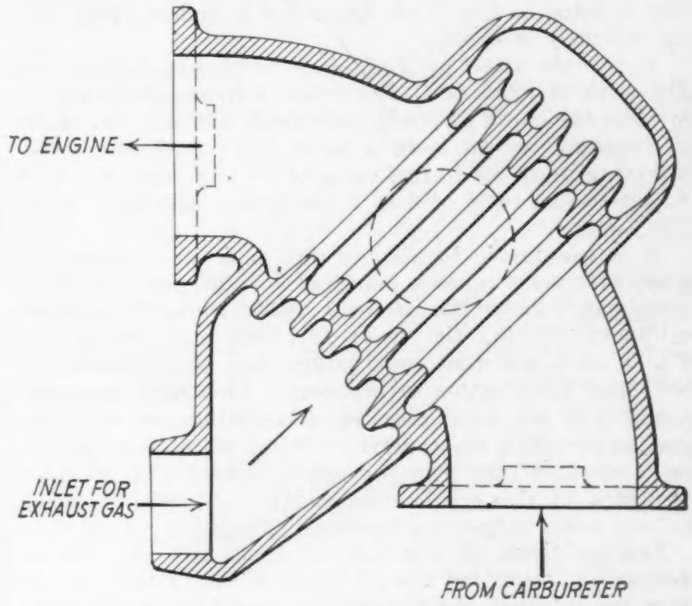

FIG. 4—ONE FORM OF FUEL TRAP OR VAPORIZER
This Construction Was Popular about 2 Years Ago and Is Still Used to Some Extent. Corrugations in the Turn of the Throat of the Manifold Are Provided To Form Pockets To Trap the Liquid Particles of Fuel Running Down the Walls and the Heat from the Exhaust Gas Passing through the Jacket Surrounding the Elbow Is Relied Upon for Their Vaporization

WHEREIN PRESENT MANIFOLDS DO NOT ACCOMPLISH UNIFORM DISTRIBUTION

Many engineers have been content to determine the fuel distribution by the power developed, assuming that the distribution is equal when the power from each cylin-

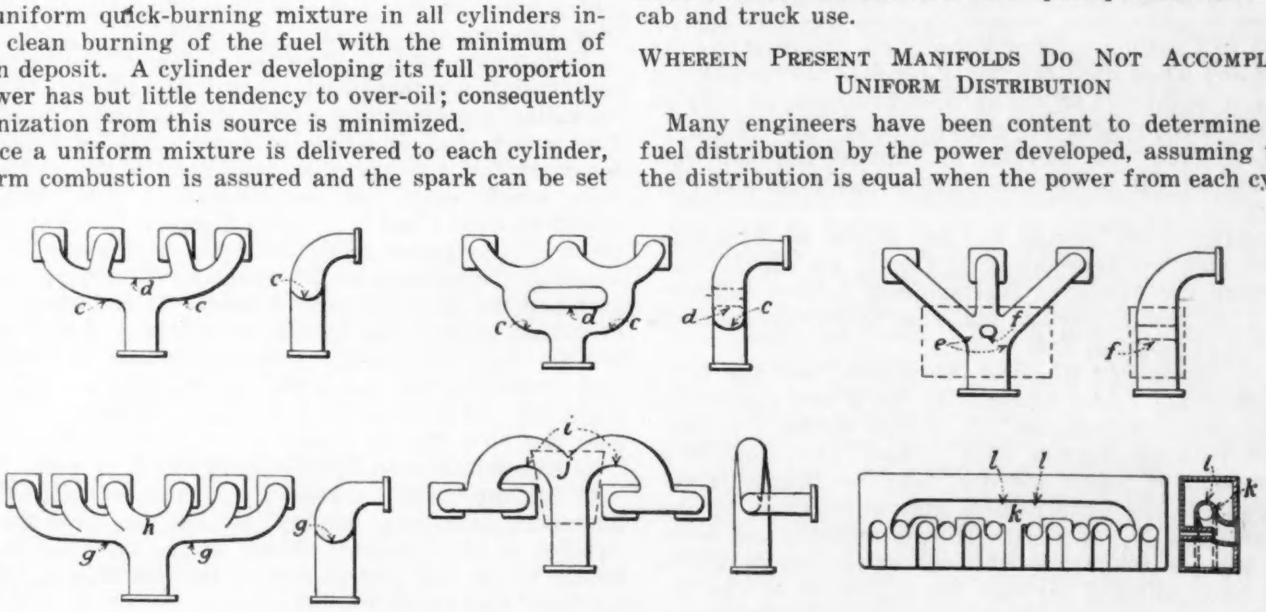

FIG. 3—CONVENTIONAL TYPES OF MANIFOLDS
In the Conventional Four-Port Manifold Illustrated in the Upper Left Corner, the Liquid Fuel Collects at *a* when the Engine Speed, and Consequently the Fuel Velocity, Is Low and the End Cylinders Receive an Excessively Rich Air-Fuel Mixture; When the Speed Is Increased the Fuel Velocity Becomes Correspondingly Higher and the Heavy Ends of the Fuel Collect at *b*, Thus Supplying an Unduly Rich Mixture to the Center Cylinders. At Low Fuel Velocities and Low Speeds the Liquid Fuel in the Three-Port Six-Cylinder Engine Manifold Shown in the Upper Central Drawing Tends To Collect at *c* and the Mixture Reaching the End Cylinders Is Unduly Rich; at High Engine Speeds the Fuel Tends To Collect at *d* and the Center Cylinders Receive an Excessively Rich Mixture. The Three-Port Six-Cylinder Engine Manifold in the Upper Right Corner Possesses the Same Characteristics as the Other Three-Port Manifold Immediately to the Left but to a More Marked Degree; the Liquid Fuel Tends To Collect at *e* at Low Speeds and at *f* as the Rate Is Increased. When a Six-Cylinder Manifold with Individual Intake-Ports, Such as Is Shown in the Lower Left Corner, Is Used, the Heavy Ends Tend To Collect at *g* when the Speed is Low and Follow the Lower Wall of the Manifold until They Reach the End Cylinders; with an Increased Speed the Point of Fuel Collection Shifts to *h* and the Heavy Ends Flow Directly to the Center Cylinders. A More Recent Manifold Design for a Four-Port Six-Cylinder Engine Is Reproduced in the Lower Central Drawing; as in the Other Manifolds a Low Speed Results in the Supply of an Excessively Rich Mixture to the Central Cylinders Due to the Tendency of the Liquid Fuel To Collect at *i*, but at the Higher Speeds the Fuel Tends To Collect at *j*, Is Carried along the Upper Wall and Drains Down by Gravity to the Distributing Manifolds. The Distribution of the Fuel to the Cylinders Depends on the Drainage Path to the Intake Ports, but the Design Is Superior to the Two and Three-Port Designs Shown. In the Lower Right Corner Is a Typical Internal Manifold for an Overhead-Valve Six-Cylinder Engine; Here the Liquid Fuel Tends To Collect at *k* when the Speed Is Low and Drains into the First Two Passages Encountered, Those Leading to Cylinders Nos. 3 and 4; at Higher Speeds the Point of Collection Shifts to *l* and the Fuel Is Carried along the Outer Wall, Draining Down by Gravity and Being Distributed among Cylinders 2, 3, 4 and 5

der is equal to that from any other cylinder. This may be seriously in error.

If, on the chart of fuel-to-air mixtures, taken from the work of Prof. O. C. Berry and reproduced in Fig. 1, we plot the curve of power developed, and also the curve of economy, we can readily select two points, one corresponding to an air-to-fuel ratio of 16 to 1, and the other an air-to-fuel ratio of 8 to 1, the power developed being the same.

It is reasonable to assume that in a six-cylinder engine, with some present manifold designs, the end cylinders may receive the 16 to 1 ratio, while the central cylinders utilizing the heavy fuel-ends may receive the 8 to 1 ratio, and that equal power may be produced but not equal distribution or economy. This may seem extreme, yet we have checked distribution on existing engines in which the central cylinders were receiving 40 per cent more fuel than the end cylinders, and the performance of the engine was considered entirely satisfactory when judged on the basis of equal power.

Another check on distribution frequently used is to observe the color and the condition of the flame issuing from the exhaust ports when the manifold is removed. This shows up bad distribution but is not a check on the quality of good distribution, nor does it afford a permanent record.

An Accurate Determination

The most accurate determination of distribution that we have used is an analysis of samples of exhaust gases taken simultaneously from the individual cylinders and the checking of these results against the fuel consumption. The equipment necessary for obtaining exhaust-gas samples is very simple, comprising glass jars filled and inverted in a shallow tank of water. The gas displaces the water and when filled the jar is removed and sealed. A series of stop-cocks on the exhaust branches, as near as possible to the engine valves, controls the flow of gas to the receivers. The samples of exhaust gas are then analyzed for carbon dioxide, carbon monoxide and free oxygen.

Applying these results to the charts of Professor Watson that are reproduced in Fig. 2, we can at once determine the excess of fuel supplied to any cylinder, since 1 per cent of carbon monoxide represents approximately 4 per cent of fuel waste.

In our discussion we have continually used the term "wet mixture." Our present-day fuels are composite, that is, they are composed of certain lighter fractions blended with the heavier ends. These fuels now have an end-point of nearly 450 deg. fahr., so that it is not practicable to use temperatures that would cause all the fuel-content to be vaporized. If such temperatures were attempted, the volumetric efficiency of the engine would be seriously affected through the expansion of the incoming air. Any temperature below this maximum would only vaporize certain fractions of the fuel, leaving the rest to be handled as a liquid in suspension, or fog. Since, to obtain equal distribution, we must distribute this fog; if we can design a system that will accomplish this result, we can as well distribute the entire quantity of fuel as a fog without the use of heat, or inversely. *Heat is not necessary to accomplish equal distribution.*

Let us now examine some conventional types of manifold to determine wherein they fail to produce equal distribution.

Distribution with Conventional Manifolds

In the diagrams shown in Fig. 3 the sections are shown as substantially round, since this is the section commonly used. In the round section the tendency of liquid fuel is to collect in the bottom and follow the definite path of flow that such a section establishes. In checking the flow of mixtures around abrupt turns, as met with in manifold work, the difference in pressure between the outer and inner walls of the bend is appreciable and measurable because of the difference of velocity head. This difference causes the liquid fuel to collect at the point of lowest pressure and velocity, the inner wall of the bend.

At the upper left corner we have a conventional four-port manifold for a six-cylinder engine. At low velocities corresponding to low engine-speeds, liquid fuel will collect at points *a* and, following the lower contour of the manifold, will enter the end cylinders, making them excessively rich. The central cylinders receive the lighter fuel-fractions and but little of the heavy ends, since the liquid fuel will not pass the gap necessary to reach the central cylinders.

Let us now examine the action of this manifold at high speeds. At high engine-speeds and the consequently high velocities of the fuel mixture, the heavy ends tend to collect at *b* where the airstream is deflected but, carried along by the velocity of the airstream, they reach the central branches and are carried to the central cylinders, which at high speeds become unduly rich.

We can readily conceive of some intermediate point at which the distribution of the heavy ends might become reasonably uniform and, coupled with the possibly wide range of fuel-to-air ratios, might develop equal power in the various cylinders. This would establish the limited effective range of performance of the particular engine, but it would be far from equal distribution or the attainable economy.

The upper central drawing shows a characteristic manifold for a three-port six-cylinder engine. At low velocities, corresponding to low engine-speeds, the liquid fuel would tend to collect at *c* and, flowing along the lower wall of the manifold, would reach the end cylinders, which would then become unduly rich. Whether cylinders Nos. 1 and 6 or 2 and 5 receive the major portions of the heavy ends would be determined by the shape of the passage in the cylinders directly above the port and the drainage path formed. It is certain, however, that under these conditions cylinders Nos. 3 and 4 are starved. At high engine-speeds and consequently high velocities, the liquid fuel would tend to collect at *d* but, carried along by the velocity of the airstream, will pass the ends of the deflector and lead to the central cylinders, which now become unduly rich in fuel.

In the upper right corner is shown a manifold for a three-port six-cylinder engine that has the same characteristics as the manifold shown in the drawing immediately to the left, but in a more marked degree. Here the liquid fuel tends to collect at *e* at low speeds and at *f* at the higher rates. In the lower left corner we have a typical six-cylinder manifold with individual intake-ports. In this manifold at low velocities the liquid fuel tending to collect at *g* is carried along the lower wall of the manifold until it reaches the end cylinders. At high speeds these heavy ends tend to collect at *h* and flow directly to cylinders Nos. 3 and 4. We can hardly assume any condition in which cylinders Nos. 2 and 5 will receive the same fuel-ratio as cylinders Nos. 1 and 6 or 3 and 4.

A more recent manifold design for a four-port six-cylinder engine is reproduced in the lower central drawing. At low engine-speeds and low velocities, the liquid fuel tending to collect at *i* is carried along the inner wall

until it reaches the central cylinders, which become unduly rich. At high engine-speeds and high velocities, the liquid fuel tending to collect at j is carried along the upper wall and, draining down by gravity, will be uniformly delivered to the distributing manifolds. Its path from here to the cylinders will be determined by the drainage path to the ports. This manifold is superior in many respects to the types previously described.

In the lower right corner we have a typical internal manifold for an overhead-valve six-cylinder engine. Here the intake passage from the carbureter might come in from either side and the end-cylinder intake-ports might be siamesed. The final results would be the same. The intake-manifold is above the valves so that the drainage path to each inlet-valve is direct. At low engine-speeds and low velocities, the liquid fuel tending to collect at k is carried along and drains into the first passages that offer, which are cylinders Nos. 3 and 4. At higher speeds, the liquid fuel tending to collect at l is carried along the outer wall but, draining down by gravity, distributes between cylinders Nos. 2 and 3 and Nos. 4 and 5. We can hardly assume, however, any condition of operation in which the end cylinders will receive the same fuel-ratio as the central cylinders.

In Fig. 4 is shown a construction that was much in favor about 2 years ago and is still used to some extent. The turn in the throat of the manifold directly above the carbureter is provided with corrugations that form pockets at the bend. The elbow is jacketed with exhaust gas. At low engine-speeds and low velocities, and especially when cold, the heavier fuel-ends pass over into these pockets from which they are eventually boiled out by the heat of the exhaust gas. At low speeds, the pockets fill with a part of the heavy ends that should have been distributed to the cylinders if the carbureter had been properly set. The mixture is therefore robbed of a portion of its fuel-content under these conditions. On accelerating, this fuel is either swept out by velocity

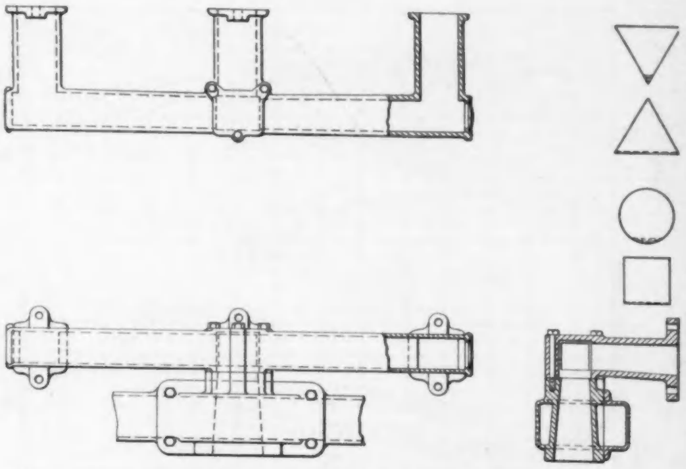

FIG. 6—A TYPE OF MANIFOLD IN WHICH THE PRINCIPLE OF EQUAL DISTRIBUTION IS EMBODIED

In This Manifold a Vertical Riser Leading from the Carbureter to the Distributing Manifold Corresponds to the Tube m in Fig. 5 and Is Acted Upon by the Suction of the Three Cylinders. The Central Portion of the Distributing Manifold Forms a Chamber from Which the Various Branches, All of Equal Area, Extend

or boiled out by heat, unduly enriching the mixture under these conditions. In other words, the action of this construction cannot be properly controlled.

In our discussion, you will observe, we have continually used the terms "fuel-mixture," since we are considering highly atomized fuel suspended in air, and "mixture condition," since our problem of distribution is to deliver to each cylinder equal portions of the heavy ends as well as of the more volatile portions.

THE SWAN PRINCIPLES OF MANIFOLDING

The principle of the Swan manifold is based on the equal distribution of wet fuel-mixtures in exactly the same ratio as that delivered to the manifold by the carbureter. Let us consider it first in an elementary way. If we have a plain vertical tube, m, Fig. 5, attached to a carbureter and acted upon by the force of suction, a mixture of air and small particles of fuel will issue which will tend to travel in straight lines until the force of suction has ceased or some other force has acted upon them. If we assume the four cylinders to be of equal capacity and equally spaced in a circle around this tube as a center, as shown in Fig. 5, and we successively impose a suction upon this tube, the fuel mixture will be deflected to the cylinders in turn and in equal quantities. If we eliminate cylinder n, the action will still remain the same for cylinders o, p and q, and we shall have the basis for a three-port manifold.

Let us now examine a Swan type of manifold, as shown in Fig. 6, to see how these principles apply. The vertical riser is shown leading from the carbureter to the distributing manifold. This corresponds to the tube shown in our diagrammatic sketch and is acted upon by the suction of the various cylinders. The central portion of the distributing manifold forms a chamber from which the various branches extend. Entering this chamber, the areas of all the branches are exactly the same. If we assume the forces in the various branches to be alike, the distribution from this central chamber will be alike in both quantity and condition. This chamber can then be considered as the metering point. It now remains to equalize the forces of suction of the various cylinders at this metering point.

The resistance of the added length of the branches to the end cylinders, together with the added change in direction, is compensated for by an increase in the mani-

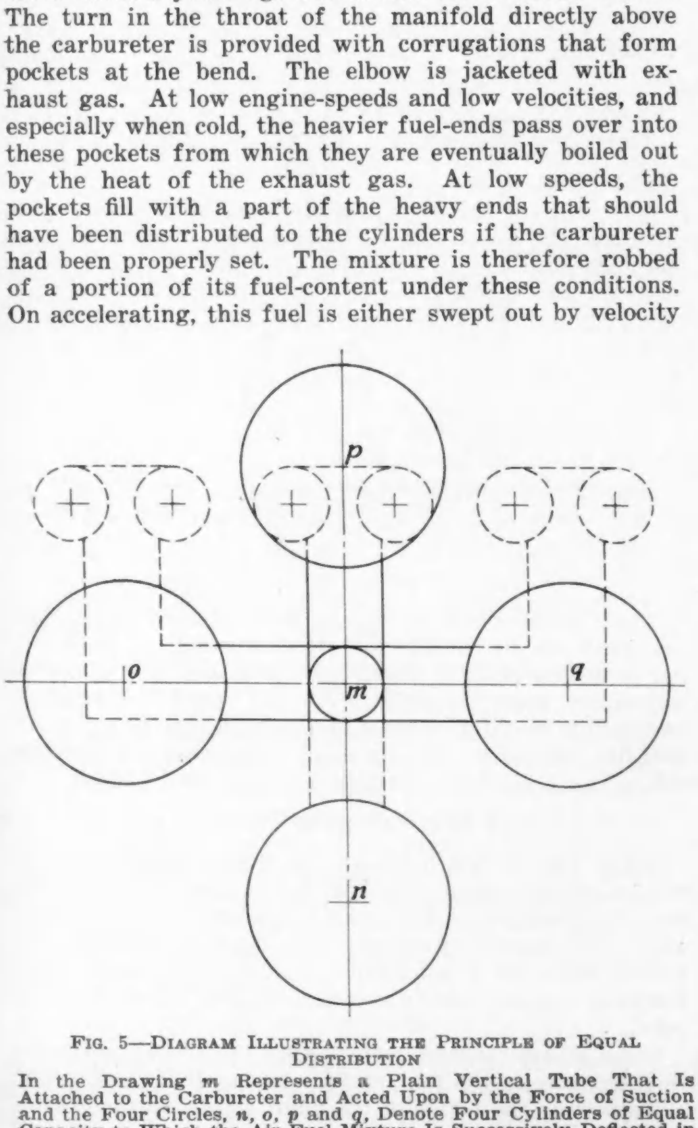

FIG. 5—DIAGRAM ILLUSTRATING THE PRINCIPLE OF EQUAL DISTRIBUTION

In the Drawing m Represents a Plain Vertical Tube That Is Attached to the Carbureter and Acted Upon by the Force of Suction and the Four Circles, n, o, p and q, Denote Four Cylinders of Equal Capacity to Which the Air-Fuel Mixture Is Successively Deflected in Equal Quantities. Eliminating the Cylinder n Does Not Affect the Principle

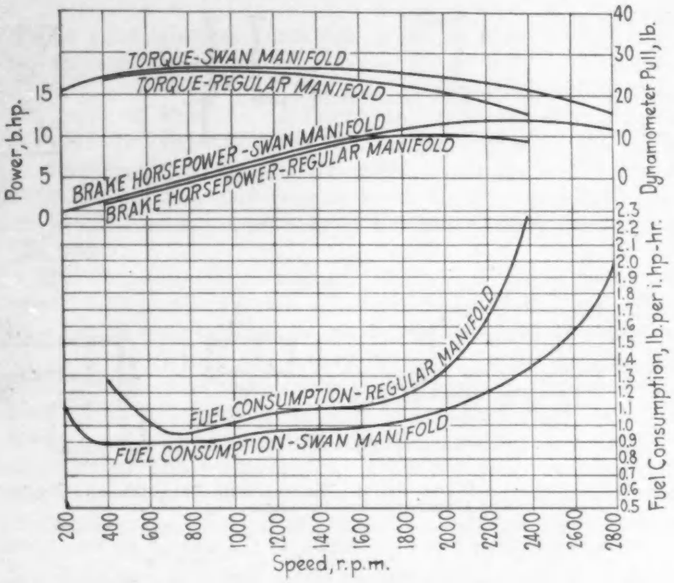

FIG. 7—COMPARATIVE BRAKE HORSEPOWER, TORQUE AND FUEL-CONSUMPTION CURVES OF THE SWAN AND A CONVENTIONAL MANIFOLD AT ONE-QUARTER LOAD

The Rapid Increase in the Fuel Consumption with the Conventional Manifold at Speeds below 800 R.P.M. Should Be Noted, Together with the Fact That This Entire Curve Is High

fold section and a decrease in the velocity. It will be noted that the section of the manifold is rectangular or square and that the floor of the distributing header is perfectly flat with no depressions; also, that the turns are abrupt and substantially at right angles. Now let us follow the passage of the fuel mixture through this manifold.

Leaving the throat of the carbureter, especially at part-throttle position, the mixture has a swirling or spiraling effect, which the change in the section of the riser from round to square tends to damp out. Also, the square section leads into the square distributing header with the desired abrupt turns. The wet mixtures that we are handling will tend to cling to the manifold walls, since during the interval of travel of the mixture to any cylinder the action in the other branches is suspended, and liquid fuel, under the action of gravity, deposits. The square section, particularly, lends itself to the control of this condition.

If a triangular section, positioned as shown in the diagram in the upper right corner, were used, the liquid fuel draining from the walls would collect in the V, as

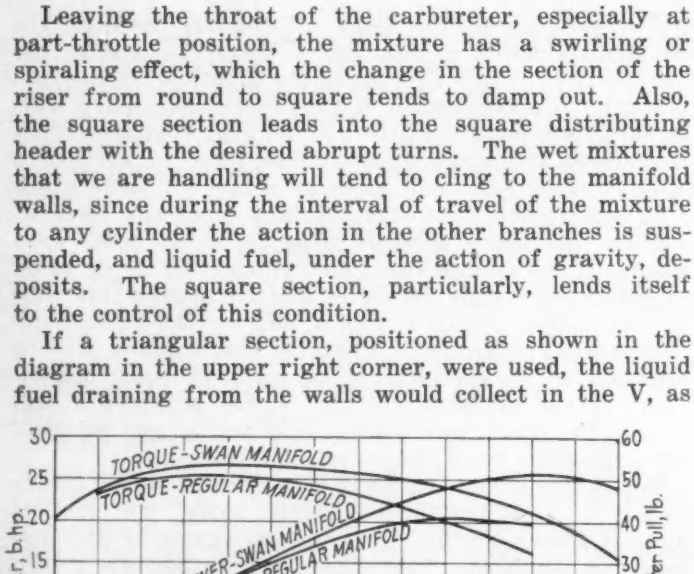

FIG. 8—ANOTHER SET OF COMPARATIVE CURVES OBTAINED AT ONE-HALF LOAD

The Fuel-Consumption Curves of Both Manifolds Are Better Than at One-Quarter Load, Although They Are Still High

shown, and would present the least surface to the airstream. If the triangle were inverted as in the diagram immediately below, the maximum floor-area would be presented, but the drainage from the side-walls would all flow to the floor.

In the circular form the drainage is similar to that shown in the lower triangle, except that the surface of the liquid collecting in the bottom would be less. Besides, the use of a circular manifold and circular ports provides nearly a direct path for liquid flow to certain cylinders. In the square section the flat floor provides the maximum area for the liquid fuel to be exposed to the airstream. The fuel collecting on the top or ceiling must fall back into the airstream to drain. The fuel collecting on the side-walls drains down and flattens out on the floor, where it is again picked up by the airstream. No pockets are provided in which any liquid fuel could collect.

It will be seen that the flow of the mixture is directed in straight lines for the maximum distance possible. Since changes in direction become necessary in the connections to the cylinders, these changes are made abruptly and at right angles. Let us examine the action at the turns.

The distributing header is extended somewhat beyond the end ports, to provide a chamber that will act to some extent as a cushion but also interrupt the direct flow of liquid fuel to the port. The liquid fuel on the inner wall, on reaching the edge of the turn, is carried off by the airstream. The liquid fuel on the upper and outer walls that collects in the end chamber must flatten on the floor and be picked up by the airstream, and cannot lead directly to the ports.

The shape of this section tends to set up a reflex action, creating the maximum turbulence and tending to keep the fuel particles in suspension. When we have delivered the fuel mixture to the respective cylinder branches, the distribution, so far as the manifold is concerned, is complete. It remains to make the valve ports in the cylinder symmetrical, with a flat floor to eliminate any preferred path of the liquid.

The features of this manifold are

(1) A straight-line manfold
(2) The holding of the atomized fuel from the carbureter in an atomized condition in the airstream to the cylinders
(3) Low first cost, which in many cases is appreciably less than that of the conventional types

That equal distribution is accomplished with this manifold can be conclusively demonstrated by driving a car equipped with a Swan manifold and a carbureter adjustable from the dash. At any speed the mixture can readily be thinned down to a point where all cylinders will fire regularly. At one point below this setting they will all quit, as if the ignition had been switched off.

THE APPLICATION OF HEAT

While heat is not necessary to realize equal distribution, a certain amount of heat is required to obtain the best performance. The rapid reduction of pressure above the throttle-valve at closed-throttle positions, together with the rapid evaporation of the lighter fuel-fractions, causes the temperature to drop below the dew-point.

Since all air contains water vapor in varying amounts, this decrease in the temperature causes the water vapor to deposit on the inside of the manifold as water or even as frost. To counteract this condition, in the Swan system sufficient heat is added to the walls to keep the

water vapor above the dew-point and prevent the liquid fuel from sticking to the walls of the vertical riser and thereby robbing the mixture of portions of its fuel-content under certain conditions and causing an over-rich mixture under other conditions.

Referring again to the sketch of the Swan manifold, Fig. 6, it will be noted that heat is applied only to the vertical riser directly above the carbureter throttle, where the greater refrigeration occurs, and that this portion is subjected to the most intense heat of the engine.

Controlled Heat versus Fixed Heat

Controlled heat, as it is termed, was developed in an effort to regulate the application of heat to the carbureter and the manifold in inverse proportion to the demands of the engine, to obtain the maximum heating at the closed-throttle positions and to cut-off the heat at the open-throttle positions where it would seriously affect the power of the engine. This heat application in practice has been found difficult to control, but we have found that a properly located application of a fixed amount of heat of the maximum intensity is entirely automatic in its action.

At part-throttle positions the velocity of the mixture through the riser is low and the transfer of heat most rapid, while at open-throttle positions with large volume and high velocities, though the heat is intense, the time-interval is so short that but little heat is absorbed per unit of mixture flowing through the riser. This corresponds to the desired ratio of temperatures and gives the desired result without the expense and complication necessary for controlled heat.

Two Periods of Warming-Up

There are two distinct periods of warming-up in a motor-car engine. The first is the heating of the intake-manifold, or certain portions of it, that we have just discussed. The second is the warming-up of the water in the jackets of the engine. A certain minimum jacket-temperature of about 120 deg. fahr. is required to obtain good performance and economy from an engine, and this is a temperature that can never be approximated in winter weather. Under such conditions the engine is operating below its efficient range of temperature, and some means of controlling the temperature of the water-jackets is advisable. This can be accomplished automatically by a thermostat in the water line, or by radiator shutters controlled either automatically or manually.

Limitations of Present Cylinder and Cylinder-Head Designs

In laying-out manifold applications to existing engines we find many limitations that prevent the realizing of the best results. In engines with internal intake-manifolds below the exhaust-ports, the lift from the bottom of the manifold to the valve face often exceeds 3½ in., a height that precludes the passing of the heavy fuel-ends into the cylinder under the low velocities occasioned by city traffic. The remedy is to raise the ports and reduce the lift to approximately 1¾ in., which can be done with marked improvement.

Results Obtained

You will recall that the various graphs of horsepower, torque and fuel consumption plotted for different engines and published by their builders invariably show full-throttle position when the engine is performing at its maximum. If the results of fractional loads on these

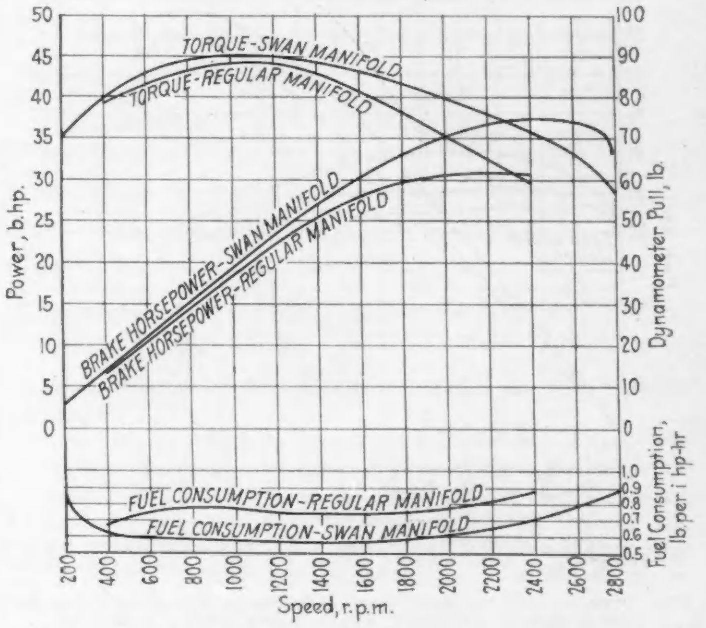

FIG. 9—COMPARATIVE BRAKE HORSEPOWER, TORQUE AND FUEL-CONSUMPTION CURVES OF THE SWAN AND A CONVENTIONAL MANIFOLD AT THREE-QUARTER LOAD

The Flattening of the Fuel-Consumption Curves and the Steeper Slope of the Brake Horsepower Curves Should Be Noted

same engines were plotted, they would not show up to the same advantage, yet the engines in service are operated at a part-throttle position 90 per cent of the time and are continually duplicating these fractional-load graphs. Comparative curves of brake horsepower, torque and fuel consumption at one-quarter, one-half, three-quarters and full loads are reproduced in Figs. 7

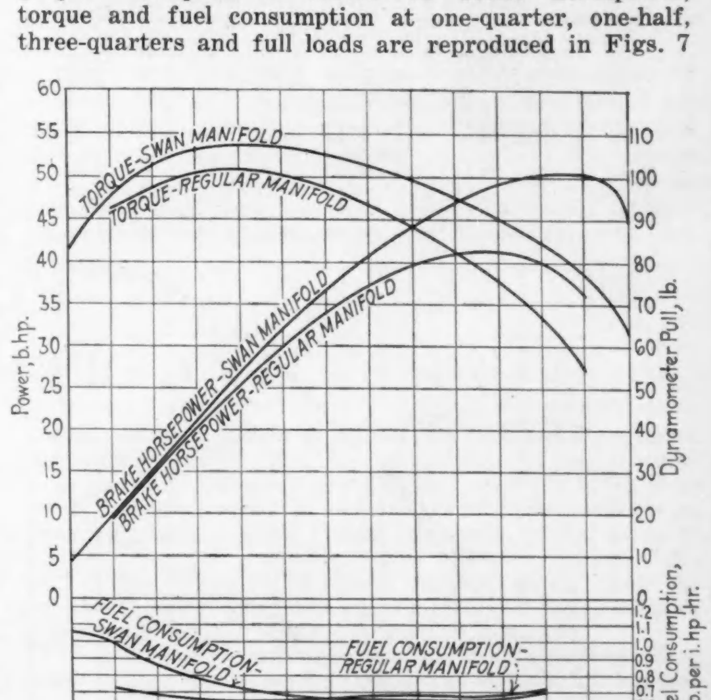

FIG. 10—ANOTHER SET OF COMPARATIVE CURVES OBTAINED AT FULL LOAD

In This Set of Fuel-Consumption Curves as Well as in Those Reproduced in Fig. 9, Accurate Readings of the Flowmeter Could Not Be Obtained at Speeds above 2400 R.P.M. so That These Points Are in Question. Steady Readings of the Dynamometer Could Not Be Obtained below 400 R.P.M. for the Conventional Manifold, but Could Be Secured at 200 R.P.M. with the Swan Manifold, Which Accounts for the Difference in the Starting Points of the Curves Reproduced in All Four Charts

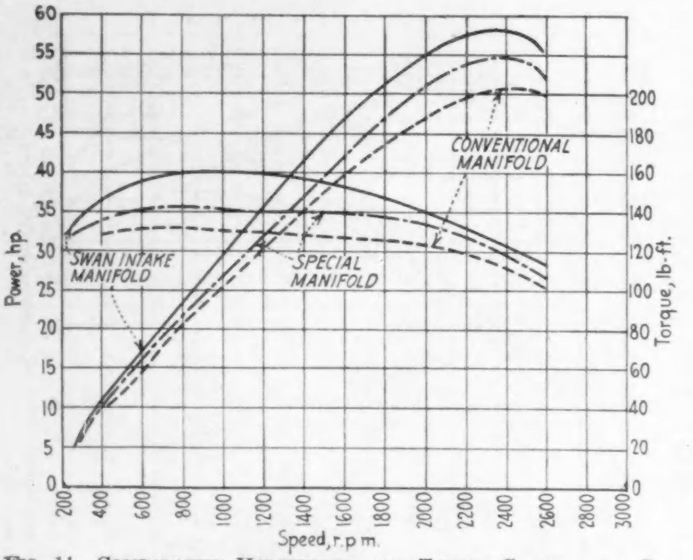

FIG. 11—COMPARATIVE HORSEPOWER AND TORQUE CURVES OF A SIX-CYLINDER 3¼ x 5-IN. ENGINE WHEN DIFFERENT MANIFOLDS WERE USED

The Improvements in the Power and Torque Resulting from the Installation of the Swan Manifold Are Readily Apparent

to 10. These show a comparison of the operation of the regular manifold and of the Swan manifold on the same engine.

TABLE 1—COMPARATIVE ANALYSIS OF EXHAUST-GAS SAMPLES TAKEN FROM THE INDIVIDUAL CYLINDERS OF A SIX-CYLINDER 3¼X4½-IN. 225-CU. IN. ENGINE AT OPEN THROTTLE AND A COMPOSITE SAMPLE FROM THE EXHAUST PIPE

Cylinder No.	Standard Manifold				Swan Manifold			
	CO_2	CO	O_2	CO_2 + CO + O_2	CO_3	CO	O_2	CO_2 + CO + O_2
1	12.20	0.00	0.60	12.80	11.40	1.40	0.00	12.80
2	10.80	2.80	0.40	14.00	11.20	1.40	0.20	12.80
3	8.40	7.00	0.40	15.80	10.60	2.30	0.10	13.00
4	8.20	8.20	0.40	16.80	10.80	2.40	0.10	13.30
5	10.80	2.20	0.40	13.40	11.10	1.70	0.20	13.00
6	11.80	0.00	0.40	12.20	10.50	2.50	0.30	13.30
Total	62.20	20.20	2.60	85.00	65.60	11.70	0.90	78.20
Average	10.37	3.37	0.43	14.17	10.93	1.95	0.15	13.03
Exhaust Pipe	9.60	4.10	0.30	14.00	10.30	1.00	0.30	11.60

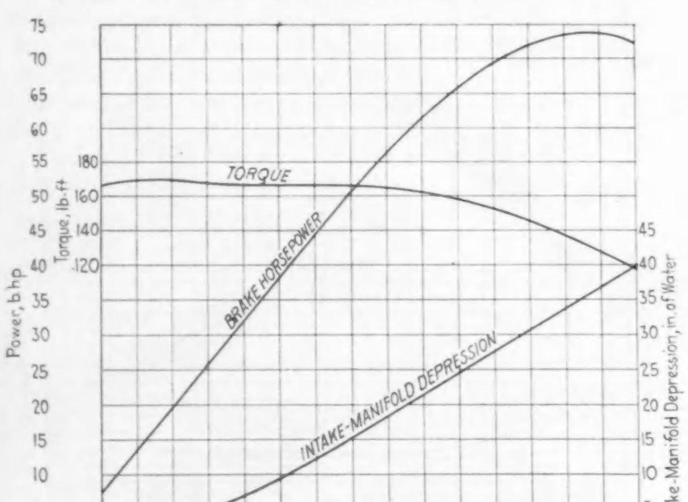

FIG. 12—CHART OF MANIFOLD DEPRESSIONS

In Addition to the Curve Showing the Variation in the Manifold Depression with Increases in the Speed of a Six-Cylinder 3⅜ x 5-In. Engine, Horsepower and Torque Curves Are Also Reproduced. The Remarkable Uniformity in the Depressions Occurring in the Center and the End Branches from the Lowest to the Highest Speeds Is Brought Out in Table 3

In Fig. 7 you will note that with the regular manifold the increase in fuel consumption per horsepower-hour is rapid at speeds below 800 r.p.m. and that the curve is high throughout. It will be noted, from this as well as the three following charts, that the graphs for the standard manifold start at 400 r.p.m. Steady readings on the dynamometer could not be obtained below this point. With the Swan manifold perfectly steady readings were obtained at 200 r.p.m. under the same conditions of load.

In Fig. 8, which is a graph at half-load, the fuel curves are better but still high. Figs. 9 and 10 are graphs of the engine at three-quarter and at full load, respectively. Accurate readings of the flowmeter could not be obtained at speeds above 2400 r.p.m. at full load; so these points are in question.

Fig. 11 is a reproduction of the comparative curves of three manifolds on a six-cylinder 3¼ x 5-in. engine. The

TABLE 2—COMPARATIVE ANALYSIS OF EXHAUST-GAS SAMPLES TAKEN FROM THE INDIVIDUAL CYLINDERS OF A SIX-CYLINDER 3⅜X4½-IN. 243-CU. IN. ENGINE AT PART THROTTLE AND 1150 R.P.M. AND A COMPOSITE SAMPLE FROM THE EXHAUST PIPE

Cylinder No.	Standard Manifold				Swan Manifold			
	CO_2	CO	O_2	CO_2 + CO + O_2	CO_2	CO	O_2	CO_2 + CO + O_2
1	8.40	4.80	3.60	16.80	12.00	0.20	0.60	12.80
2	10.60	4.90	0.20	15.70	11.60	0.20	0.40	12.20
3	9.80	6.20	0.10	16.10	11.40	0.30	0.40	12.10
4	9.40	6.50	0.60	16.50	11.40	0.40	0.60	12.40
5	9.80	5.50	1.70	17.00	11.60	0.60	0.80	13.00
6	9.90	5.70	0.40	16.00	12.00	0.20	0.60	12.80
Total	57.90	33.60	6.60	99.10	70.00	1.90	3.40	75.30
Average	9.65	5.60	1.10	16.52	11.67	0.32	0.57	12.55
Exhaust Pipe	10.30	4.60	0.90	15.80	11.80	0.30	0.60	12.70

manifold marked "special" is a modification of the conventional manifold. The curves, which are self-explanatory, show the actual improvements obtained by installing the Swan manifold on existing engines. These are actual, not theoretical, curves.

To demonstrate that equal distribution is actually accomplished with the Swan manifold, we have given in Tables 1 and 2 two comparative exhaust-gas analyses from engines equipped with a regular manifold and with a Swan manifold.

The wide variation in the carbon-monoxide content, as well as the high values to be noted in Table 1, are to be compared with the reduction and uniformity of the second analysis given in Table 2, which shows what can be accomplished in the way of distribution and the consequent fuel-economy at part-throttle, corresponding to ordinary city driving. It may be a question in the minds of many engineers whether the resistances of the various branches and turns can be equalized as we have stated.

TABLE 3—INTAKE-MANIFOLD DEPRESSIONS, MEASURED IN INCHES OF WATER AT VARIOUS SPEEDS, FOR A SIX-CYLINDER 3⅜ X 5-IN. ENGINE HAVING A PISTON DISPLACEMENT OF 268 CU. IN.

Speed, R.P.M.	Depression in End Manifold	Depression in Center Manifold	Difference
400	2¼	2¼	0
600	3	3	0
800	4½	4½	0
1,200	8½	8½	0
1,600	14¼	15	¾
2,000	21⅛	21	⅛
2,200	24	24	0
2,400	26¾	26¼	½
2,600	30¾	30	¾
2,800	34½	33¼	1¼
3,000	38½	36	2½
3,200	43	40	3

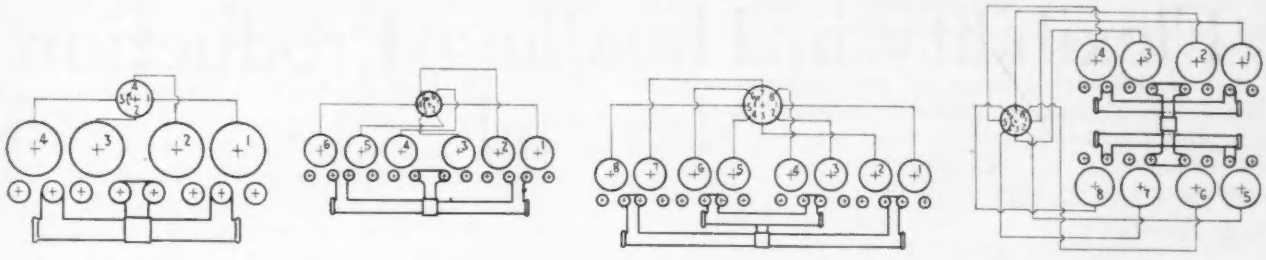

FIG. 13—DIAGRAMS OF ENGINE MANIFOLDS
At the Extreme Left the Manifold Design of a Typical Four-Cylinder Engine, in Which the Firing Order Is 1-3-4-2, Is Outlined; Immediately to the Right Is a Sketch of the Manifold Arrangement for a Six-Cylinder Engine Having a Firing Order of 1-5-3-6-2-4; Next Comes a Similar Diagram for a Straight-Eight Engine, in Which the Firing Order Is 1-3-2-5-8-6-7-4, and at the Extreme Right the Manifold Arrangement of a V-Type Eight-Cylinder Engine Having a Firing Order of 1-5-3-7-4-8-2-6

In Fig. 12 is given a chart showing, at varying speeds and in inches of water, the depressions occurring in the center and end branches of a three-port Swan manifold for a six-cylinder engine. The remarkable uniformity, from the lowest to the highest speeds, which cover the effective range of present motor-car engines, is to be noted.

SWAN MANIFOLD A UNIVERSAL TYPE

It is evident from our previous discussion that the principles of the Swan manifold are applicable to all engines, independently of the number of cylinders. Let us examine the diagrams reproduced in Fig. 13 to judge how these principles apply.

In the diagram at the extreme left we have a typical four-cylinder engine with the conventional 1-3-4-2 firing-order. With this cylinder arrangement we bring out individual intake-ports for cylinders Nos. 1 and 4 and siamese the intake-ports for cylinders Nos. 2 and 3. This gives us a three-port manifold, something new in four-cylinder practice. Let us follow the induction order as shown by the firing order. Cylinder No. 1 draws first through the forward branch, followed by cylinder No. 3 through the central branch. Next, cylinder No. 4 draws through the rear branch and, last, cylinder No. 2 through the central branch. In this design the direction of flow at the metering point is changed for each cylinder and there are no successive flows in any branch of the manifold. This ensures equal distribution and obviates the inertia effects of the mixture column in the various branches.

The second diagram from the left shows a characteristic three-port six-cylinder engine with a firing order 1-5-3-6-2-4. This order, as well as the arrangement 1-4-2-6-3-5, has the same characteristics as that of the four-cylinder type, in that the succeeding flow of mixture is always in a different branch and in a different direction from that of the metering point.

The right central diagram shows an eight-in-line engine with the firing order 1-3-2-5-8-6-7-4. This would be similar to the four-cylinder engine if two cylinders and two inlet-valves were substituted for each single one in the four-cylinder type, the flow from the metering point having the same characteristics.

The diagram at the extreme right shows a V-type eight-cylinder engine with firing order 1-5-3-7-4-8-2-6. This again has the same characteristics as those preceding. It is evident, then, that the Swan manifold, so far as conventional motor-car engines are concerned, is a universal type.

There is an insistent demand for better methods of utilizing fuel in motor cars. The sudden widespread interest of engineers in improved distribution of the fuel and in other features of engine design that have to do with the handling of fuel, together with the proved soundness and merit of Swan principles, makes us confident that the standardization of manifolding is not far off.

HIGHWAY-TRAFFIC ANALYSIS

G. E. HAMLIN, of the Connecticut Highway Commission, in an article appearing in a recent number of the *Engineering News-Record* points out that a differentiation must be made between a highway-traffic census and a highway-transport survey. The former, he points out, will give information pertaining to the traffic using the highway at the time the census is taken, while the purpose of the latter is to determine the probable amount and character of the future traffic that will use a given highway during the lives of its several component parts.

A highway-traffic census is of value only for determining conditions existing at the time the census is taken. After an extended census, Mr. Hamlin recommends that additional counts be taken at critical periods of the year in succeeding years, from which, after a number of counts have been taken, curves of natural increase can be plotted to serve as a basis for determining roughly an estimate of the increased traffic for a reasonable number of years. This estimate should also include the curve of increase of motor-vehicle registration from one year to another.

The value of an extended traffic-survey in determining the allocation of construction and maintenance funds in the development of a highway system is unquestioned. Such a survey, however, should be utilized for type and strength of the surface, rather than for the location of expenditures since the development of new territory within a State is as much a demand upon the expenditure of highway funds as the taking care of traffic already developed, in Mr. Hamlin's opinion. This point, he adds, cannot be stressed too strongly, for, if the allocation of funds depends wholly upon the volume of traffic only, few of the roads in any particular State would ever receive a construction allotment.

To carry out a traffic survey successfully much planning must be done preliminary to the actual field work. Stations must be chosen that will give the average condition along each highway and these must be located at a sufficient distance from the congested centers to eliminate, as far as possible, the strictly local traffic that will not enter into the construction program. Care should also be taken to establish stations where traffic is divided, so that the value of each section as well as each road can be determined. Each station should be occupied at least one day every month, for an 8 to 12-hr. period. This should be arranged so that the same station will be occupied successively on different days of the week and on a different hourly basis to determine the daily as well as the seasonal variation of traffic.

Flexibility in Handling Production Material

By A. A. Brown[1]

Annual Meeting Paper

COMMENDING the service of supplies of the Allies during the war as an example of the successful operation of a flexible distributing system and comparing the problems of a modern factory to a small army operating on a very active front, the author describes a simple, elastic and practical method of effectively handling materials that is in vogue throughout the various units of a large automobile factory. Like that of most other plants, the system under discussion has been developed by a process of evolution since the time when the layout consisted of a single small building with the departments adjacent to one another and has been gradually extended to cover the ramifications of widely separated units.

With elasticity as the keynote of the system, the stockrooms are scattered and the materials are placed promiscuously throughout the plant near the places of their consumption in as large quantities as possible. Those in charge are allowed to use discretion as to the routing and to decide which parts are to undergo thorough inspection and which ones may be sent direct to the points of assembling. If the needs of production demand it, material may be hurried through the inspection department or an inspector may follow it to the assembling line.

Material is transported by electric or motor trucks. Hand trucking is not permitted except in otherwise inaccessible places. Gravity conveyors are used extensively. Materials are held in the stockroom only because it affords a place in which to store large quantities and because it minimizes the possibility of theft of parts that function equally well on cars of other makes. Service-department requirements are supplied directly from production stock, which is replaced when it becomes materially decreased; a perpetual inventory is not kept, as it is considered cumbersome and expensive, defeating its own purpose and slowing up the delivery of material. One of the functions of such an inventory is filled by a shortage report that is made out when notice has been received from a stock-clerk or a foreman that the quantity of any part is getting low. An advantage of maintaining low stocks is that, if changes are made in parts, the new parts can be substituted quickly without waiting for a large stock of old material to be used up. The only stock records kept are those of the purchasing department, to which the stock department has access and which it assists in compiling. Stock-chasers go through this list each day to determine whether the material received is up to specifications and whether a shortage is likely to arise. By analyzing the men and carefully selecting the personnel of the material-distribution division flexibility is capitalized and adaptations to changing conditions are quickly made.

IT is very generally conceded that the success of the Allies in the war is attributable to the fact that their service of supplies was efficiently organized and operated. I would go further than that and, from certain personal knowledge and observations, would say that the service of supplies was not only efficiently organized and operated but that an element of flexibility was allowed and encouraged, which played a most important part in the success of the whole. By this I mean that latitude was exercised by officers and men in distributing and routing of quickly needed materials that might otherwise have suffered ignominious deterioration by the wayside if subjected to the ponderous mercies of the dear old army regulations and their attendant miscellany of reports, sub-reports and super-reports. "Circumstances alter cases" was the awakening cry, and that such a policy was successful when finally put into effect is now a matter of history.

The modern automobile plant is like a small army in operation on a very active front. Its problems are akin to those of the army, in intensity at least, though in a lesser degree so far as quantity and variety of materials are concerned. The necessity is there for uninterrupted smooth operation, for the adequate and sensible handling of materials. And that great industrial god, Efficiency, can best be served by taking advantage of all the existing systems that provide competent assistance and bending them to the will by introducing an element of flexibility in their operation.

Assuming, then, that an effective method of handling materials in an automobile plant is absolutely essential to its successful existence, the object of this paper is to outline a simple, elastic and practical system now in use throughout the various manufacturing units of the company that I represent. The method we employ is the result of a sort of gradual evolution, rather than of definite planning. Difficulties have arisen from time to time that had to be met and overcome in the best way possible according to the existing conditions and circumstances.

The present layout, springing from a single small building and developing into many acres of ground and thousands of square feet of floor space, comprises a main plant and several subsidiary companies. At the beginning, the problems were much more simple because the receiving, inspection and stock departments were adjacent to one another. All incoming material went naturally from the receiving to the inspection department and from there to the stock department; no other route that it could travel was possible. Now each department is composed of a number of widely separated units controlled from the executive offices.

This condition intensifies our problem and makes an elastic method imperative. Were we able to continue having these three departments joined and centrally located, it would still be possible to dole out small quantities of material, enough for a day's supply or for a certain quantity production. Instead, we place our materials promiscuously throughout the plant near the place of consumption and in quantities as large as possible. Our stockrooms are scattered. Though the system is decidedly one of decentralization, it renders the material more easily available and greatly reduces the cost of handling, which, after all, is a very important factor, since each time a part is moved its cost increases.

[1] Stock manager, Chandler Motor Car Co., Cleveland.

Routing and Handling Materials Through the Receiving Department

To cope with the situation, materials must be promptly and properly received, and they must be wisely routed and transported in the correct manner. In that word "wisely" lies the key to our success in handling materials swiftly. Through it, individuals of known ability are allowed to use discretion in the routing, and though their decisions are not always the same, they are always made "for the good of the service." All materials are considered as stock that is available for production immediately upon their receipt, and no deduction is made from stock records unless one of three future conditions obtains:

(1) Stock is shipped back to the original vender for one reason or another
(2) Stock is shipped to another manufacturing plant for further work
(3) Stock is scrapped and necessary records made

Detailed written instructions are issued to the receiving department relative to the physical handling of incoming stock, counting and recounting the number of pieces, making out and routing the proper records and reports and the like. This phase of the work is very similar to that of other manufacturing plants. The receiving clerk must be a man of better-than-average intelligence, for upon him depends the personal efficiency of the checkers and the freight handlers. We all are familiar with the short-comings of human nature that lead men to shorten their labor by guessing at the contents of a box, especially if they can in some way obtain a look at the packing slip. Very often the receiving clerk, by the exercise of a little tact and diplomacy, can have certain quantities counted and recounted by different men without any damaging information passing between them.

An inspector thoroughly acquainted with the production methods of the organization and possessed of a thorough knowledge of the care with which material should be handled is the man best adapted to route material properly through the plant. He understands what material must go to the parts inspection department, to undergo a rigid 100-per cent inspection, and he also knows what can be sent directly to one of a number of inspection stations located conveniently near the assembling lines.

At this juncture it is well to lay stress on what is perhaps the dominant phase of the flexibility of our stock methods. As has been stated before, the inspector in the receiving department arbitrarily routes all incoming material. He does so, however, under the explicit orders of his superior, the chief inspector. If the needs of production demand that certain materials be moved to the lines more rapidly, the production manager or the stock manager makes the fact known to the receiving inspector, who hurries that material through the inspection department, if it must go there, or asks his chief to send an inspector directly to the assembly line or to the shops, where it is immediately inspected.

All rejected or damaged material must go to the salvage department. If rejected on a vendor, shipping orders are requested for its return but, if damaged in the plant, it is forthwith scrapped, provided the inspectors of the salvage department consider the damage sufficient to impair its quality.

Transportation Within the Plant

The correct manner of transporting material when conveyors cannot be used is by electric or motor trucks. Hand trucking is not permitted except in places where an electric or motor truck cannot gain access. All incoming material in the receiving department is placed on portable platforms or boxes constructed so that they can easily be moved from one department to another with an electric truck of the elevating-platform type. Special platforms are provided for moving axle assemblies, engine-pans, steering-spindles, rear-axle housings and a host of other items.

In the machine shop, gravity conveyors are used very extensively. Chandler engines are built on specially-designed stands with casters that fit into angle-iron tracks. After the engines have been completed, they are conveyed to the block test department by an overhead conveyor. The entire chassis is assembled on a conveyor of the chain type. The bodies are brought from the body department to the assembly lines by a conveyor that carries them from the fourth floor of one building through an underground passage to the third floor of another building. In the entire plant, all unnecessary hand labor has been studiously eliminated.

The Stocking of Materials

Materials are held in the stockroom, not to keep records of them but merely to afford a place for storing large quantities and to minimize the possibility of theft of parts, such as motometers, windshield cleaners, spark-plugs and many others too numerous to mention, that function equally well in other makes of car. Since quantities of all materials are always available at the production lines, it becomes necessary to maintain constant vigilance to see that the correct parts that are specified in the bill of material are assembled for the particular type of car being built. When a new type of car is produced, such information is received from the engineering department, and all the foremen must be informed of the changes and instructed to use the proper parts.

In a similar manner, the burdens of our chief inspector are not lightened by our method. He is directly responsible for the quality of the component parts and the assembling of the car, and must, therefore, arrange cleverly to accomplish his task under what might be considered adverse circumstances. Inspection of material sent to the inspection department is not difficult, but the flexibility of the stock-handling system requires an inspection system equally flexible and at the same time absolutely definite as regards getting an inspection of all the material that is routed past the parts inspection department.

Service Department Requirements

Service department requirements for all parts that are used in current-model cars are supplied directly from production stock. In this manner, the cost of those parts to the service department is identical with the cost of the same part in production. Save for a small anticipated service allowance, no particular additions are made to regular releases to provide for service needs. The service department, however, is constantly drawing on production and in the course of a few months or a year reduces the production stock materially; it then becomes necessary to make another purchase to replace the shortage. Our company seldom if ever gages the quantities required by the records alone, but a physical inventory of the material on hand is demanded. One might imagine that a perpetual inventory, telling exactly how much of each kind of material is on hand and where it is located, would serve us to good advantage, but such

an inventory compiled from a complete system of stock requisitions is cumbersome and expensive and defeats its own purpose. It appreciably slows-up the movement of material because quantities must constantly be verified, not only by the department delivering, but also by the one receiving such material.

The Shortage Report and Its Significance

We approach the results that are obtained in a perpetual inventory by the use of a shortage report on which there are three classifications: 300 to 500, 100 to 300 and 50-car shortages. Every stock-clerk in the organization is instructed to report to his immediate superior when he first learns that the quantity of any part appears to be getting low. Every foreman, without having definitely been ordered to do so, informs the stock manager or his assistant when he believes that a shortage of any material that his department requires is impending. This practice is most healthful and operates to the mutual benefit of the foreman and of the stock department. To produce what is expected and to enable him to keep his men steadily employed a foreman usually becomes a most dogged stock-chaser, and the only way to make him a fit man to live with is to furnish the material he needs.

It is very true that a shortage does not actually exist every time one is reported but, when such a report is made, it at least causes an investigation to be made to learn the exact status of that particular part. The assistant stock manager, knowing where all parts are stored and also where they are machined or assembled, makes a daily tour of the plant to verify the shortages reported on that day and also those that were carried forward from the report of the previous day. If he finds the shortages to be actual, they are added to the shortage report of the following day.

In a measure, the length of the shortage report is directly proportional to the success of an organization. A great number of parts on shortage means that the inventories are not excessively high and consequently less capital is held dormant. It does no harm to let material run low, excepting, perhaps, that the transportation charges necessary to get the material in quickly are more excessive than they would be if the material were allowed to come by freight. Another feature of a small inventory works to the advantage of the engineering department. A change of design is always a refinement and the sooner a change can be incorporated into any part, the greater are the benefits to be derived. If the engineering department must wait until some time in the future before making the change, because the management has decreed that great quantities of old material must first be used, they no doubt often find that a competitor has out-guessed them and "stolen their thunder." A consistently small inventory reduces the length of time before such changes can be incorporated. On finding new parts on the shortage reports, the purchasing department releases material still outstanding on purchase orders or, upon the advice of the purchasing agent, issues new purchase orders.

Stock Records

The shortage report is by no means the only method by which shortages become known. We use a form drawn up for an Elliott-Fisher machine that shows as well as such a record can the exact conditions of all production material. On one portion of that form the salient records pertaining to the receipt of materials are entered; to the side are listed the totals for which they have been invoiced and on the remainder of the record are posted the service usage, scrap and other losses. Deductions are made here of the quantities used in production. The last column gives the net balance on hand. These sheets are filed in binders in such a manner that each binder contains only the venders' names that have been assigned to a stock-chaser. The stock-chaser must go through his list each day to determine whether the material being received is up to specifications and also to determine from the net total on hand whether a shortage is likely to arise.

Here it may be well to show the manner in which our stock records differ from those of many automobile companies. The only stock records that we have are those kept by the purchasing department to which the stock department has free access and in the compiling of which the stock department lends valuable assistance. By combining the records of these departments, one entire clerical force is eliminated. Both departments are dependent solely on the bill of material; the purchasing department to know what quantities to buy for certain release and the stock department to know what to issue to production. The bill of material is the Magna Charta of any automobile company.

Conclusion

The great factor in handling stock is the character and the ability of the men employed to look after this work. We have heard much and read much about the "human element" in business, but what we have heard and read has been largely about the big fellows at the top, or the small proprietor and the salesman who mingle with the buyers "on the firing line." All true, no doubt, but I want to tell you that the human element in the handling of stock is something that it would pay any executive to look into every now and then. A so-called system of handling material is no better than the individuals who operate that system, elaborate and carefully planned though it may be. The right men in the right places can show you weaknesses in what you thought to be a foolproof and efficient method; that is, they can point out flaws and better economies if they wish to, if they are interested enough in their job and in the company to do so. It is by analyzing our men and sometimes by changing their employment that we are able to maintain a stock-handling method that is more efficient because of the absence of too many hide-bound instructions. It is due to the personnel of our material-distribution division that we can capitalize on flexibility and adapt ourselves quickly to conditions as they change from time to time.

Winter Tests Show Greater Dilution with Heavy Fuels

By JOHN A. C. WARNER[1]

ANNUAL MEETING PAPER *Illustrated with* CHARTS

BECAUSE the analyses of many samples of new and of diluted crankcase oil had not been completed by the Bureau of Standards when the results of the winter tests were reported at the 1923 Semi-Annual Meeting, the report on these dilution data was delayed. This information has since become available and forms the basis of this paper.

After reviewing the results of the winter tests as already reported, stating the names of the cooperating companies and tabulating the cars and the mileage distribution in the test runs, the author discusses the results of the analyses of fresh crankcase oils and the dilution results before making a comparison between those obtained under summer and under winter conditions.

Dilution versus mileage, the subjects of dilution, viscosity and specific gravity and the distillation of composite oil samples are presented next, followed by comments upon crankcase-oil consumption. Numerous tables and charts are included, and a summary of the results is made. In the appendix, a report is made of a set of parallel runs with both a commercial gasoline and a special winter fuel that was conducted by one of the cooperating companies in addition to the regular tests described in this paper and in the previous report.

FOLLOWING the road-service tests conducted during the summer of 1922 by 10 of the larger automobile-building companies, it was thought desirable to repeat the runs in winter to show the effects at low temperatures of different fuel-volatilities upon fuel consumption, crankcase-oil dilution and engine performance. This work was carried on by the experimental departments of the companies in cooperation with the Society's Research Department as a part of the fuel research program undertaken by the Society, the National Automobile Chamber of Commerce, the American Petroleum Institute and the Bureau of Standards. The major portion of the general investigation has been handled by the Bureau of Standards.

Most of the results of the winter tests were reported in a paper by H. C. Dickinson and J. A. C. Warner, entitled Winter Tests Show Lower Mileage with Heavy Fuels,[2] which was presented at the 1923 Semi-Annual Meeting of the Society. At that time the analyses of the large number of samples of new and diluted crankcase oil had not been finished at the Bureau of Standards; consequently, the July report was incomplete in this respect. The dilution material has since become available, however, and forms the basis of this paper.

In review, it will be recalled that the winter tests showed an increase of 3 per cent in the average fuel-consumption accompanying an increase of about 55 deg. fahr. in the 90-per cent point of the distillation curves reproduced in Fig. 1. When compared with the estimated 30-per cent difference in the relative amounts of the two extreme grades of fuel obtainable from a given quantity of crude, this relatively small difference in mileage is unimportant.

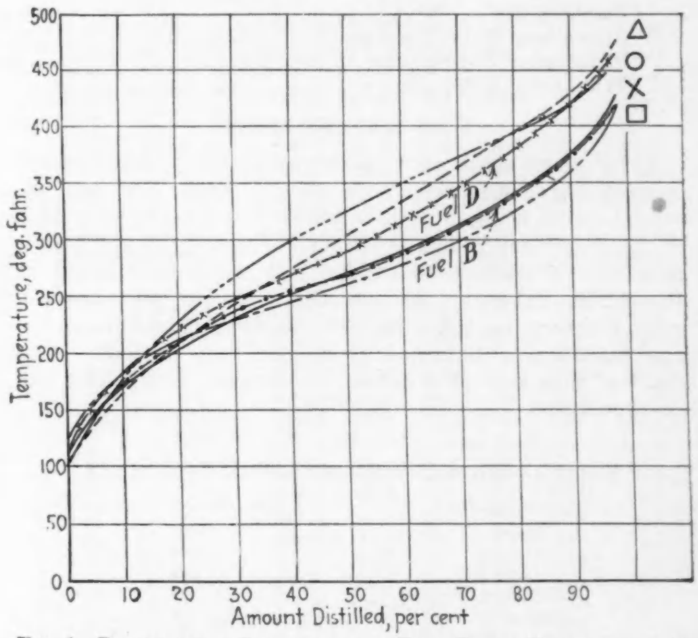

FIG. 1—DISTILLATION CURVES OF THE FOUR FUELS USED BY THE 10 AUTOMOBILE COMPANIES AND OF THE *B* AND *D* FUELS USED IN THE BUREAU OF STANDARDS TESTS

However, interesting differences between the fuels were noted with respect to starting and general engine performance. The drivers reported with remarkable consistency that the fuels of higher volatility were noticeably superior in these characteristics. The differences corresponded to the relative volatilities between the 14 and 20-per cent points of the distillation curves. This is of particular interest because of the relatively small temperature differences existing in this range. All possibility of prejudice and preconceived ideas had been eliminated by designating the four fuels with symbols □, X, O and △ and by keeping from the drivers all information pertaining to the fuels.

The general procedure, which was similar to that of the summer tests, was arranged to eliminate, from the final averages, as far as possible, the effects of changes in weather and in the individual characteristics of cars and drivers. The cars were among those used in ordinary service by members of the cooperating companies. The technical staff of each organization was responsible for the conduct of the tests, the filling with fuel and oil and the reporting of the results. All samples of new and used crankcase oil were forwarded to the Bureau of Standards where complete analyses were made and reported both to the companies and to the Research Department.

[1] M.S.A.E.—Assistant manager of the research department, Society of Automotive Engineers, Inc., New York City.

[2] See THE JOURNAL, July, 1923, p. 87.

Cooperating Companies

Of the 10 companies listed below as cooperating in the tests, one did not complete the work in time for the results to be included, and the results reported by another were obtained by methods so different from those generally adopted as to make unwise their inclusion in a comparative analysis of this nature.

- Autocar Co.
- Buick Motor Co.
- Dodge Bros., Inc.
- Ford Motor Co.
- Hupp Motor Car Corporation.
- International Harvester Co.
- Packard Motor Car Co.
- Stromberg Motor Devices Co.
- Studebaker Corporation of America.
- Waukesha Motor Co.

Cars and Mileages

Fifty-seven stock cars representing the product of the cooperating companies were used. Each car was operated on its regular daily schedule for 1 week with each of the four fuels. The mileages covered by the different cars during each week of the test were distributed as shown in Table 1, the greatest number of car-week mileages ranging between 100 and 199. The total mileage 50,136 was obtained from 226 test periods. The shortest run was 39.8 miles, the longest 1014.0 and the average 222.0.

Table 1—Mileage Distribution in Test Runs

Distance, Miles	Number of Runs
39–99	30
100–199	108
200–299	40
300–399	20
400–499	13
500–599	10
600–699	2
700–799	1
800–899	1
1000–1014	1

Fuels

Fig. 1 shows the distillation curves for the winter fuels □, X, O and △ and for two of the summer fuels *B* and *D*.[3] It was specified that one of the winter fuels should be identical with fuel *B* and another identical with fuel *D*. A third was to have the same 90-per cent point as fuel *B* but a lower 10-per cent point, while a fourth was to have the same 90-per cent point as fuel *D* and a 10-per cent point like that mentioned above. The fuels supplied by the refiners did not meet with the specifications as well as was desired but were used because time was lacking for their replacement.

Fresh Crankcase Oils

The results of analyses of fresh crankcase oils used in different groups of cars are shown by Table 2. The viscosities at 100 deg. fahr. ranged from 320 to 202 Saybolt sec., while the specific gravities ranged from 0.935 to 0.879. Average Saybolt viscosities at 100 deg. fahr. were 283, 270, 281 and 277 for the fresh oils used with fuels □, X, O and △ respectively. The average specific gravity was 0.911 for each of the four sets of fresh oils. The highest flash and fire points were 435 and 490 deg. fahr. respectively while the lowest were 320 and 380 deg. fahr. respectively.

[3] See The Journal, January, 1923, pp. 3 and 118; also February, 1923, p. 139.

TABLE 2—ANALYSES OF NEW OILS

Used in Cars	Gravity, Specific	Gravity, Baumé	Flash Point, Deg. Fahr.	Fire Point, Deg. Fahr.	Viscosity at 100 Deg. Fahr., Saybolt Sec.
Groups 1 and 2	0.879	29.2	435	490	320
Groups 3, 4 and 5	0.935	19.6	355	395	300
	0.935	19.6	345	400	301
Group 6	0.907	24.3	410	475	290
Group 7	0.932	20.2	355	420	306
Group 8	0.897	26.2	395	465	279
Group 9 △ fuel	0.928	20.8	320	395	334
Group 9 ○ fuel	0.930	20.5	325	390	354
Group 9 □ fuel	0.926	21.1	340	400	397
Group 9 × fuel	0.930	20.5	320	380	236
Groups 10, 11 and 12	0.903	25.0	390	445	202
Group 13	0.913	23.3	370	425	235

Dilution Results

To determine the relative dilution of crankcase oil resulting from the use of fuels of different volatilities, particular attention was paid to the analysis of samples taken from the crankcase after each run with a given fuel. The results of analyses of the used-oil samples as reported by the Bureau of Standards are given in Tables 3 to 6 inclusive; while Table 7 presents a summary of the grand averages taken from the four tables that precede it. The values for percentage dilution were obtained in each case by placing 100 cc. of the used oil in an Engler flask and then distilling at atmospheric pressure up to the boiling temperature of the fresh oil. The number of cubic centimeters of distillate was taken as the percentage dilution.

TABLE 3—ANALYSES OF USED OILS WHEN □ FUEL WAS USED IN CARS

Used in Car No.	Gravity, Specific	Gravity, Baumé	Flash Point, Deg. Fahr.	Fire Point, Deg. Fahr.	Viscosity at 100 Deg. Fahr., Saybolt Sec.	Dilution, Per Cent
1	0.870	30.9	160	270	199	11.4
2	0.872	30.5	160	270	179	11.5
3	0.873	30.3	200	345	215	9.0
4	0.870	30.9	170	325	184	13.5
Group 1 Average	0.871	30.6	172	302	194	11.3
5	0.872	30.5	200	490	226	10.0
6	0.871	30.7	190	475	196	10.0
7	0.869	31.1	165	260	159	14.4
8	0.871	30.7	205	445	209	10.0
Group 2 Average	0.871	30.7	190	417	197	11.1
9	0.909	23.9	150	175	90	20.8
10	0.920	22.2	190	225	129	12.5
11	0.919	22.3	165	240	123	14.0
12	0.908	24.1	145	175	79	21.5
Group 3 Average	0.914	23.1	162	204	105	17.2
13	0.913	23.2	180	210	92	19.5
14	0.921	22.0	170	240	127	10.5
15	0.927	21.0	215	315	176	28.0
16	0.917	22.6	160	215	112	15.0
Group 4 Average	0.919	22.2	181	245	127	18.3
17	0.913	23.3	155	195	95	18.0
18	0.920	22.1	180	265	149	9.0
19	0.921	21.9	190	230	130	13.3
20	0.905	24.6	140	175	70	24.0
Group 5 Average	0.915	22.9	166	216	111	16.1

TABLE 3—ANALYSES OF USED OILS WHEN □ FUEL WAS USED IN CARS (*Concluded*)

Used in Car No.	Gravity Specific	Gravity Baumé	Flash Point, Deg. Fahr.	Fire Point, Deg. Fahr.	Viscosity at 100 Deg. Fahr., Saybolt Sec.	Dilution, Per Cent
21	0.918	22.5	200	305	163	6.5
22	0.903	25.0	170	290	153	9.0
23	0.898	25.9	160	255	159	11.5
24	0.898	25.9	170	245	131	15.4
25	0.899	25.7	180	275	172	11.0
26	0.898	25.9	160	245	145	13.0
Group 6 Average	0.902	25.1	173	269	154	11.1
27	0.920	22.2	195	135	165	11.0
28	0.912	23.5	195	215	132	11.2
29	0.912	23.5	170	190	112	14.0
30	.....	....	...	...	...	....
Group 7 Average	0.915	23.1	186	180	136	12.1
31	0.886	28.0	175	205	138	16.0
32	0.889	27.4	145	195	139	15.3
33	0.892	26.9	155	305	221	6.5
34	0.883	28.3	135	160	113	22.0
35	0.888	27.6	180	210	147	....
36	0.886	28.0	150	190	142	11.5
Group 8 Average	0.887	27.7	156	211	150	14.3
37	0.908	24.1	175	205	112	21.5
38	0.919	22.3	200	245	124	14.0
39	0.897	26.0	135	150	71	31.0
40	0.910	23.8	170	220	132	17.4
41	0.912	23.5	170	210	128	19.5
Group 9 Average	0.909	23.9	170	206	113	20.7
42	0.894	26.6	170	240	110	12.5
43	0.895	26.4	150	170	96	12.1
44	0.889	27.5	135	190	87	18.5
45	0.889	27.5	155	200	90	16.4
Group 10 Average	0.892	27.0	152	200	96	14.9
46	0.893	26.8	155	220	99	13.0
47	0.883	28.6	125	160	95	21.7
48	0.897	26.1	160	225	112	13.0
49	0.892	27.0	145	195	110	12.0
Group 11 Average	0.891	27.1	146	200	104	14.9
50	0.889	27.5	145	205	93	14.0
51	0.895	26.4	175	270	123	9.0
52	0.891	27.1	140	170	87	18.5
53	0.897	26.1	150	200	111	13.5
Group 12 Average	0.893	27.0	152	211	103	13.7
54	0.906	24.5	170	305	147	8.3
55	0.902	25.2	150	230	122	11.0
56	0.906	24.5	165	365	157	6.0
57	0.907	24.3	160	250	148	6.4
Group 13 Average	0.905	24.6	161	287	143	7.9
Grand Average	0.898	25.8	167	243	134	14.2

TABLE 4—ANALYSES OF USED OILS WHEN × FUEL WAS USED IN CARS

Used in Car No.	Gravity Specific	Gravity Baumé	Flash Point, Deg. Fahr.	Fire Point, Deg. Fahr.	Viscosity at 100 Deg. Fahr., Saybolt Sec.	Dilution, Per Cent
1	0.871	30.7	185	475	194	12.6
2	0.870	30.9	170	255	184	13.0
3	0.874	30.1	195	475	188	14.5
4	0.869	31.1	180	345	195	15.0
Group 1 Average	0.871	30.7	182	387	190	13.8

TABLE 4—ANALYSES OF USED OILS WHEN × FUEL WAS USED IN CARS (*Continued*)

Used in Car No.	Gravity Specific	Gravity Baumé	Flash Point, Deg. Fahr.	Fire Point, Deg. Fahr.	Viscosity at 100 Deg. Fahr., Saybolt Sec.	Dilution, Per Cent
5[a]	0.877	29.6	255	500	359	9.0
6	0.873	30.3	200	415	203	10.5
7	0.872	30.5	185	410	190	11.6
8	.....	....	...	...	...	....
Group 2 Average	0.873	30.4	193	413	197	11.1
9	0.908	24.1	145	175	77	22.0
10	0.914	23.1	165	210	97	18.5
11	0.916	22.7	190	215	108	15.8
12	0.912	23.5	155	185	90	12.0
Group 3 Average	0.912	23.3	164	196	93	17.1
13	0.893	26.7	150	170	55	35.0
14	0.921	22.0	185	220	125	14.2
15	0.911	23.6	190	215	87	23.0
16	0.916	22.8	175	200	102	17.0
Group 4 Average	0.910	23.8	175	201	92	22.3
17	0.915	22.9	145	185	97	17.5
18	0.912	23.5	185	200	93	19.8
19	0.919	22.3	165	235	120	12.6
20	0.899	25.6	155	165	63	29.0
Group 5 Average	0.911	23.6	162	196	93	19.7
21	0.903	25.0	190	315	177	8.5
22	0.901	25.3	170	270	155	10.4
23	0.900	25.5	200	395	167	10.5
24	0.902	25.2	190	265	149	10.5
25	0.902	25.2	185	280	159	11.0
26	0.904	24.8	180	270	151	9.8
Group 6 Average	0.902	25.1	186	299	160	10.1
27	0.924	21.5	180	260	199	9.5
28	0.908	24.2	155	275	95	20.0
29	0.912	23.5	190	215	107	14.5
30	0.915	23.0	185	220	120	13.5
Group 7 Average	0.915	23.1	177	242	130	14.4
31	0.884	28.3	145	195	120	18.0
32	0.892	26.9	150	190	159	10.0
33	0.890	27.3	145	240	148	12.2
34	0.874	30.1	125	170	82	25.1
35	0.886	28.0	145	210	138	13.0
36	0.885	28.0	150	195	129	14.0
Group 8 Average	0.884	28.1	143	200	129	15.4
37	0.914	23.1	165	215	107	18.5
38	0.877	29.6	180	235	108	14.5
39	0.898	25.9	140	165	69	26.0
40	0.918	22.5	185	245	146	12.7
41	0.910	23.8	170	200	104	17.0
Group 9 Average	0.903	25.0	168	212	107	17.7
42	0.894	26.6	175	285	107	12.0
43	0.891	27.0	150	195	125	17.0
44	0.889	27.5	145	200	95	14.5
45	0.887	27.8	145	195	89	16.0
Group 10 Average	0.890	27.2	154	219	104	14.9
46	0.891	27.1	155	215	102	12.0
47	0.888	27.7	115	160	75	21.4
48	0.895	26.3	145	230	115	11.5
49	0.897	26.0	130	185	110	13.5
Group 11 Average	0.893	26.8	136	197	100	14.6

TABLE 4—ANALYSES OF USED OILS WHEN × FUEL WAS USED IN CARS (*Concluded*)

Used in Car No.	Gravity		Flash Point, Deg. Fahr.	Fire Point, Deg. Fahr.	Viscosity at 100 Deg. Fahr., Saybolt Sec.	Dilution, Per Cent
	Specific	Baumé				
50	0.893	26.7	160	265	118	10.5
51	0.892	26.9	155	215	106	12.3
52	0.897	26.0	135	175	96	17.0
53	0.892	26.9	165	230	110	12.3
Group 12 Average	0.893	26.6	154	221	108	13.0
54	0.900	25.5	145	230	109	13.9
55	0.901	25.2	145	220	119	10.5
56	0.898	25.9	150	215	103	14.9
57	0.904	24.8	145	240	136	10.0
Group 13 Average	0.901	25.3	146	226	117	12.4
Grand Average	0.897	26.0	164	241	123	15.1

[a] Values not included in average.

TABLE 5—ANALYSES OF USED OILS WHEN O FUEL WAS USED IN CARS

Used in Car No.	Gravity		Flash Point, Deg. Fahr.	Fire Point, Deg. Fahr.	Viscosity at 100 Deg. Fahr., Saybolt Sec.	Dilution, Per Cent
	Specific	Baumé				
1	0.869	31.1	190	280	167	11.3
2	0.867	31.4	155	240	125	19.5
3	0.870	30.9	215	305	180	15.5
4	0.869	31.1	180	265	164	15.0
Group 1 Average	0.869	31.1	185	272	159	15.3
5	0.871	30.7	215	330	213	8.7
6	0.867	31.4	175	210	116	24.2
7	0.861	32.6	185	215	93	29.5
8	.....	....	...	...	...	....
Group 2 Average	0.866	31.6	192	252	141	20.8
9	0.900	25.5	140	180	65	22.3
10	0.904	24.8	160	190	69	27.7
11	0.909	23.9	175	200	85	21.5
12	0.897	26.0	165	185	59	33.6
Group 3 Average	0.902	25.0	160	189	70	26.3
13	0.910	23.8	190	220	82	13.8
14	0.912	23.4	180	205	89	20.8
15	0.922	21.9	175	245	128	13.0
16	0.907	24.3	175	195	78	25.5
Group 4 Average	0.913	23.3	180	216	94	18.3
17	0.915	22.9	185	235	103	17.5
18	0.901	25.3	160	190	64	29.0
19	0.915	23.0	180	220	98	19.3
20	0.884	28.4	145	165	47	42.0
Group 5 Average	0.904	24.9	170	202	78	27.0
21	0.902	25.2	190	250	120	14.5
22	0.902	25.2	155	200	107	19.7
23	0.898	25.9	170	240	114	15.9
24	0.888	27.6	160	195	78	28.0
25	0.888	27.6	165	195	83	26.5
26	0.893	26.7	170	220	99	22.0
Group 6 Average	0.895	26.4	170	216	100	21.1
27	0.905	24.7	180	210	83	22.0
28	0.874	30.2	160	170	44	48.6
29	0.896	26.3	165	180	66	29.0
30	0.912	23.5	170	220	75	22.5
Group 7 Average	0.897	26.1	169	195	67	30.5

TABLE 5—ANALYSES OF USED OILS WHEN O FUEL WAS USED IN CARS (*Concluded*)

Used in Car No.	Gravity		Flash Point, Deg. Fahr.	Fire Point, Deg. Fahr.	Viscosity at 100 Deg. Fahr., Saybolt Sec.	Dilution, Per Cent
	Specific	Baumé				
31	0.882	28.7	150	190	100	22.7
32	0.877	29.6	145	195	78	28.6
33	0.886	28.0	150	200	111	19.0
34	0.873	30.1	145	185	76	27.0
35	0.885	28.1	175	220	124	16.4
36	0.878	29.4	160	190	88	24.5
Group 8 Average	0.880	29.0	185	197	96	23.0
37	0.907	24.3	160	195	104	20.0
38	0.904	24.8	190	220	87	24.5
39	0.905	24.7	170	205	93	23.0
40	0.894	26.6	155	180	65	32.5
41	0.891	27.1	150	165	61	34.0
Group 9 Average	0.900	25.5	165	193	82	26.8
42	0.893	26.7	195	260	107	15.0
43	0.880	29.0	140	165	58	....
44	0.864	31.9	145	165	48	40.5
45	0.877	29.5	145	175	63	29.5
Group 10 Average	0.879	29.3	156	191	69	28.3
46	0.866	31.6	125	155	50	37.3
47	0.862	32.3	110	125	46	39.5
48	0.890	27.3	160	205	87	18.7
49	0.890	27.3	140	185	89	18.5
Group 11 Average	0.877	29.6	134	167	68	28.5
50	0.884	28.4	160	200	78	21.5
51	0.882	28.7	160	190	73	25.0
52	0.886	28.0	150	175	71	27.0
53	0.890	27.3	155	190	79	18.0
Group 12 Average	0.885	28.1	156	189	75	22.9
54	0.898	25.9	175	215	99	17.3
55	0.894	26.6	155	215	97	21.0
56	0.902	25.2	170	165	130	10.5
57	0.895	26.4	140	180	85	21.0
Group 13 Average	0.897	26.0	160	194	103	17.4
Grand Average	0.890	27.3	164	205	92	23.5

TABLE 6—ANALYSES OF USED OILS WHEN △ FUEL WAS USED IN CARS

Used in Car No.	Gravity		Flash Point, Deg. Fahr.	Fire Point, Deg. Fahr.	Viscosity at 100 Deg. Fahr., Saybolt Sec.	Dilution, Per Cent
	Specific	Baumé				
1	.....	....	...	...	...	....
2	0.862	32.4	185	225	122	[a]24.5
3	0.869	31.1	200	290	164	14.6
4	0.864	32.0	170	215	123	19.5
Group 1 Average	0.865	31.8	185	243	136	19.5
5	0.869	31.1	210	310	188	16.0
6	0.868	31.2	180	245	159	16.5
7	0.862	32.4	180	230	115	23.5
8	0.868	31.2	195	265	156	20.2
Group 2 Average	0.867	31.5	191	262	154	19.1
9	0.903	25.0	155	180	65	28.5
10	0.901	25.3	185	210	66	31.5
11	0.907	23.4	170	193	90	21.5
12	0.919	22.3	180	230	122	15.7
Group 3 Average	0.908	24.0	172	203	86	24.3

TABLE 6—ANALYSES OF USED OILS WHEN △ FUEL WAS USED IN CARS (*Concluded*)

Used in Car No.	Gravity, Specific	Gravity, Baumé	Flash Point, Deg. Fahr.	Fire Point, Deg. Fahr.	Viscosity at 100 Deg. Fahr., Saybolt Sec.	Dilution, Per Cent
13	0.909	24.0	185	220	47	27.0
14	0.912	23.4	170	210	92	20.0
15	0.924	21.5	195	260	129	14.0
16	0.903	25.0	175	205	66	9.0
Group 4 Average	0.912	23.5	181	224	84	17.5
17	0.909	23.9	185	205	83	22.8
18	0.907	24.3	165	190	78	22.8
19	0.911	23.6	180	220	90	21.5
20	0.893	26.7	145	175	53	36.5
Group 5 Average	0.905	24.6	169	197	76	25.9
21	0.904	24.8	180	230	86	20.5
22	0.895	26.4	155	220	98	20.0
23	0.889	27.4	160	180	86	24.0
24	0.886	28.0	150	190	73	28.5
25	0.889	27.4	155	195	82	26.5
26	0.885	28.1	140	185	81	28.0
Group 6 Average	0.891	27.0	157	200	84	24.6
27	0.904	24.9	180	195	79	26.3
28	0.901	25.4	170	195	71	27.7
29	0.896	26.3	170	190	63	32.0
30	0.912	23.5	175	220	104	9.7
Group 7 Average	0.903	25.0	174	200	79	23.9
31	0.880	29.0	145	195	89	28.0
32	0.888	27.6	175	205	135	15.4
33	0.886	28.0	160	210	124	16.0
34	0.871	30.5	144	185	66	32.5
35	0.882	28.7	155	200	105	20.1
36	0.876	29.8	150	240	85	25.0
Group 8 Average	0.881	28.9	155	206	101	22.8
37	0.894	26.6	165	180	62	34.5
38	0.890	27.3	165	195	59	36.5
39	0.863	32.2	140	160	40	57.5
40	0.892	26.9	160	175	60	39.0
41	0.896	26.2	150	185	68	32.0
Group 9 Average	0.887	27.8	156	179	58	39.9
42	0.884	28.3	170	225	75	26.0
43	0.880	29.0	165	190	69	25.5
44	0.881	28.9	145	185	67	25.6
45	0.881	28.9	165	200	68	25.7
Group 10 Average	0.881	28.8	161	200	70	25.6
46	0.881	28.9	155	195	66	25.5
47	0.875	27.7	140	170	85	30.5
48	0.885	28.2	150	190	76	23.0
49	0.887	27.8	140	200	100	19.0
Group 11 Average	0.882	28.1	146	189	82	24.5
50	0.886	28.0	165	205	78	19.5
51	0.889	27.5	175	220	85	21.0
52	0.881	28.9	135	180	66	26.5
53	0.887	27.8	175	195	87	19.5
Group 12 Average	0.886	28.1	162	200	79	21.6
54	0.898	25.9	170	225	100	15.7
55	0.896	26.2	160	210	90	19.0
56	0.906	24.5	175	345	158	8.0
57	0.894	26.6	150	220	97	12.5
Group 13 Average	0.898	25.8	164	250	111	13.8
Grand Average	0.890	27.3	166	210	91	23.7

TABLE 7—SUMMARY OF ANALYSES OF USED OILS—GRAND AVERAGE VALUES

Fuel Used	Gravity, Specific	Gravity, Baumé	Flash Point, Deg. Fahr.	Fire Point, Deg. Fahr.	Viscosity at 100 Deg. Fahr., Saybolt Sec.	Dilution, Per Cent
□	0.898	25.8	167	243	134	14.2
×	0.897	26.0	164	241	123	15.1
O	0.890	27.3	164	205	92	23.5
△	0.890	27.3	166	210	91	23.7

Referring to Table 7 and to Fig. 1 it is seen that the relative percentages of dilution for the four fuels followed the volatility arrangement between the 80 and 97-per cent points of the fuel-distillation curves; that is, the greatest dilution resulted from the use of △ fuel, the least volatile, and the dilution decreased with the increasing volatility for fuels O, X and □ respectively. The average mileage for runs with the four fuels was approximately the same. Considering the fuels in two groups, it is noted that a difference of 55 deg. exists at the 90-per cent point of the distillation curves between □-X and O-△ groups whose average percentages of dilution were 14.7 and 23.6 respectively. The viscosities of the oils were changed in turn from an average of 278 Saybolt sec. at 100 deg. fahr. for the fresh oils to averages of 128 and 92 Saybolt sec. at 100 deg. fahr. for the respective groups of diluted oils, □-X and O-△. Average specific gravity changed from 0.911 to 0.897 and 0.890 for the respective groups.

Summer and Winter Comparison

Owing to the lower operating temperatures, crankcase-oil dilution becomes more serious in winter than in summer. In a relatively cold engine the fuel is less completely vaporized and a greater portion finds its way into the crankcase oil and remains there.

TABLE 8—COMPARISON OF AVERAGE PERCENTAGE OF DILUTION FOR SUMMER AND WINTER TESTS

Fuels / Car Nos.	Winter: □ and ×	Winter: O and △	Summer: *A*	Summer: *B*	Summer: *C*	Summer: *D*
10 and 20	21.0	34.4	6.5	8.9	11.9	14.2
9 and 18	17.9	25.7	6.1	6.8	9.4	13.2
42-45	14.9	26.9	7.5	9.5	12.0	13.3
46-49	14.8	26.5	7.1	10.1	12.5	18.1
50-53	13.4	22.3	7.5	8.3	11.3	16.1
Average of Above Values	16.4	27.1	6.9	8.7	11.4	15.0

To throw additional light on the relative importance of the problem under different conditions of temperature, Table 8 has been prepared to show a comparison of average dilutions on identical or similar cars using similar fuels in both summer and winter. It is noted that summer fuel *B* averaged 8.7-per cent dilution against 16.4 per cent for the □-X winter group; and that summer fuel *D* averaged 15.0-per cent dilution compared with 27.1 per cent for the O-△ winter group.

TABLE 9—AVERAGE SUMMER AND WINTER TEMPERATURES IN DEGREES FAHRENHEIT

Car Nos.	Weekly Average Lowest, Summer	Weekly Average Lowest, Winter	Weekly Average Highest, Summer	Weekly Average Highest, Winter	Average for All Tests, Summer	Average for All Tests, Winter
9, 10, 18 and 20	63	29	72	35	68	33
27-30	62	33	75	44	69	39
31-36	63	33	70	44	67	39
42-53	53	33	66	44	61	39

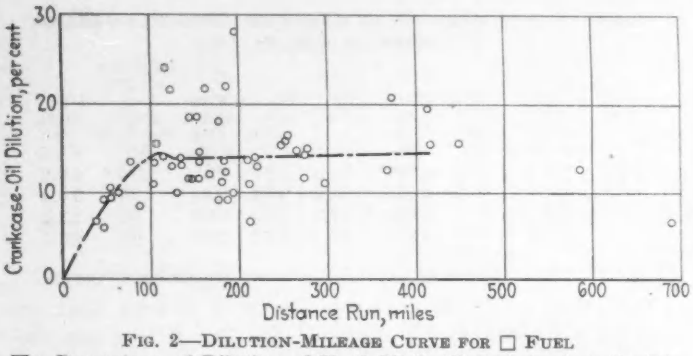

FIG. 2—DILUTION-MILEAGE CURVE FOR □ FUEL
The Percentage of Dilution of Used Oil Is Plotted Against the Distance in Miles for Separate Runs of All Cars Using □ Fuel

In Table 9 are given average summer and winter temperatures for the cars listed in Table 8. An average temperature-difference of 29 deg. fahr. is shown for all tests.

DILUTION VERSUS MILEAGE

Investigators have expressed many and varied opinions concerning the manner in which the dilution of crankcase oil changes with continued operation. Some have believed that dilution increases more or less regularly and indefinitely until the oil becomes very highly diluted, while others have asserted that a state of equilibrium is reached after a certain period when as much fuel leaves the oil as enters it.

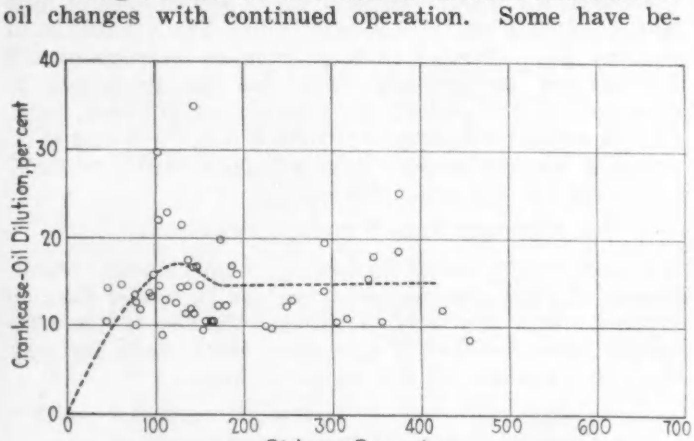

FIG. 3—DILUTION-MILEAGE CURVE FOR X FUEL
The Percentage of Dilution of Used Oil Is Plotted Against the Distance in Miles for Separate Runs of All Cars Using X Fuel

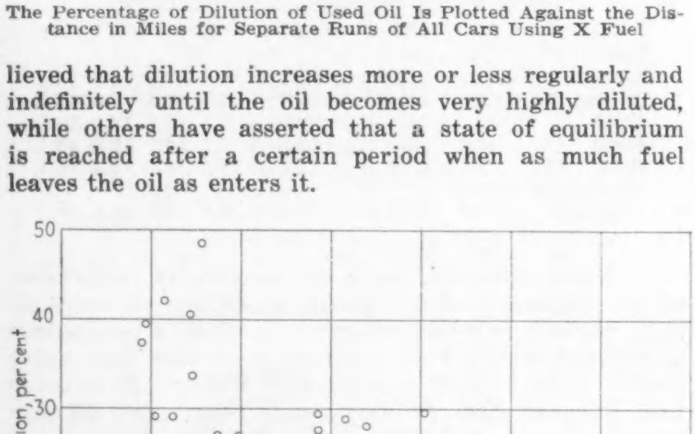

FIG. 4—DILUTION-MILEAGE CURVE FOR O FUEL
The Percentage of Dilution of Used Oil Is Plotted Against the Distance in Miles for Separate Runs of All Cars Using O Fuel

While the road-service tests were not planned to determine this point in particular, it is possible nevertheless to gather certain indications as to the dilution process by noting the percentages of dilution that prevailed after runs of different lengths.

With this in view, percentage dilution was plotted against miles run for each car and fuel as shown in Figs. 2 to 5 inclusive. It is noted that the points are widely scattered and an explanation of the method of obtaining the curves may be of interest. Starting from the left each chart was divided vertically and progressively into equal groups of points; the number of points being chosen arbitrarily. The co-ordinates represented by each group of points were then averaged both vertically and horizontally thus leaving a single average point to represent the group. These average points for the four fuels were then transferred to another chart and are shown in Fig. 6.

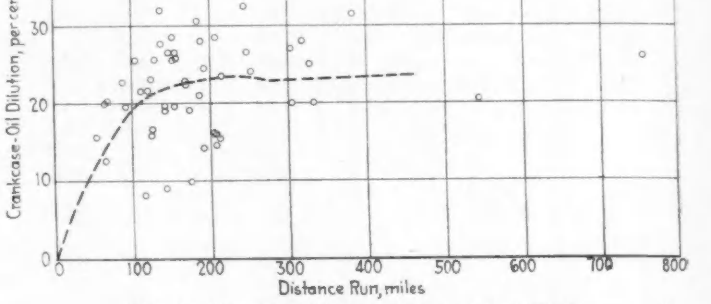

FIG. 5—DILUTION-MILEAGE CURVE FOR Δ FUEL
The Percentage of Dilution of Used Oil Is Plotted Against the Distance in Miles for Separate Runs of All Cars Using Δ Fuel

Attention is called to the fact that, owing to the nature of these curves, due care should be exercised in their interpretation. The dilution values *were not taken at different mileages from a single car,* but from many cars whose runs varied greatly, thus making the conditions of operation different for each point. Account should be taken of the fact that these conditions, especially temperature, were not the same for short as for long runs. However, the curves clearly indicate the grouping of the fuels and the relative dilutions with respect to volatility. They also indicate that a point of approximate dilution-equilibrium was reached after runs of comparatively short duration. The shorter weekly runs represented by the points toward the left of Figs. 2 to 5 in-

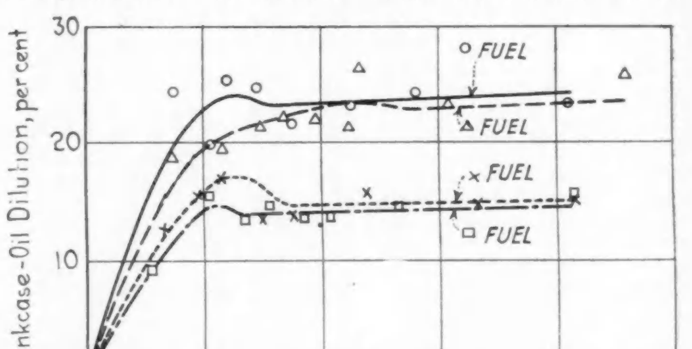

FIG. 6—DILUTION-MILEAGE CURVES FOR THE FOUR FUELS
A Comparison of the Average Curves of the Four Fuels Shown in Figs. 2 to 5, Inclusive. The Points Are Averages of Groups from Four Preceding Curves

clusive were mainly composed of very short trips during which the operating temperatures were never high. This would perhaps account for the rise in the curves at corresponding mileages.

Dilution, Viscosity and Specific Gravity

From the point of view of lubrication the viscosity of an oil is generally accepted as the most important property to be watched as changes take place. Certain authorities have even assigned a definite limit below which the viscosity cannot extend without very serious consequences. It is certain, however, that other very important factors such as dirt contamination are involved and must also be given careful consideration in the treatment of the problem.

The effects of these factors upon lubrication were not included in the present tests, but the analyses of used oils serve to show the changes that took place with increasing amounts of dilution. To give typical examples of the changes in the viscosity and the specific gravity the curves of Fig. 7 were plotted for the oils of highest and lowest viscosity when fresh. The average curve for

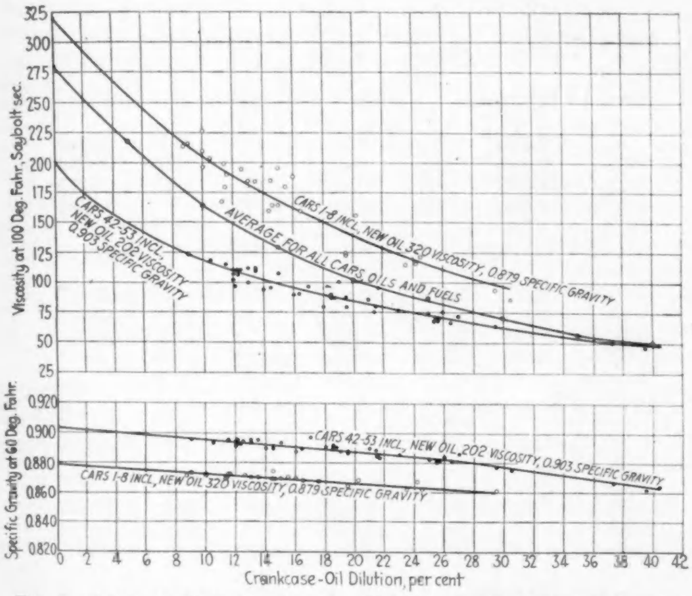

FIG. 7—DILUTION PLOTTED AGAINST VISCOSITY AND SPECIFIC GRAVITY
These Curves Represent Viscosity and Specific-Gravity Values at Various Percentages of Dilution for Two Groups of Cars Using Respectively the Oils of Highest and Lowest Viscosity when Fresh. The Plotted Points Represent Averages for Four Fuels

all oils is also shown. The points for all the curves represent averages for the four fuels.

The curves of Fig. 8 were derived from those mentioned above and show the relative variations of the viscosity and the specific gravity at different percentages of dilution for the two oils of Fig. 7.

Distillation of Composite Oil Samples

As a matter of interest, composite samples were made by mixing equal quantities of the diluted oils from all runs for each of the four fuels; thus a sort of mechanical average was obtained. Distillations were made at the Bureau of Standards for each of the composite samples. The results are shown by the curves of Fig. 9. The indicated temperatures, which were taken in the vapor, not in the liquid, were not accurate for the first 3 or 4 per cent on account of the water brought over. However, all volumes were corrected for the amount of water.

Referring to Fig. 9, the values for samples diluted with different fuels run along close together until they separate to form the two groups with respect to

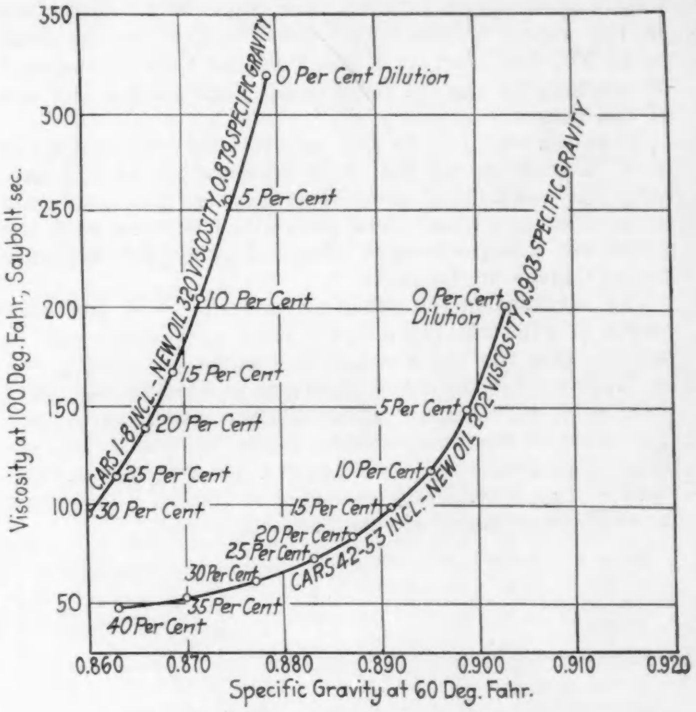

FIG. 8—SPECIFIC GRAVITY-VISCOSITY CURVES
Specific Gravity and Viscosity for Different Amounts of Dilution Are Plotted for the Cars and Oils of Fig. 7

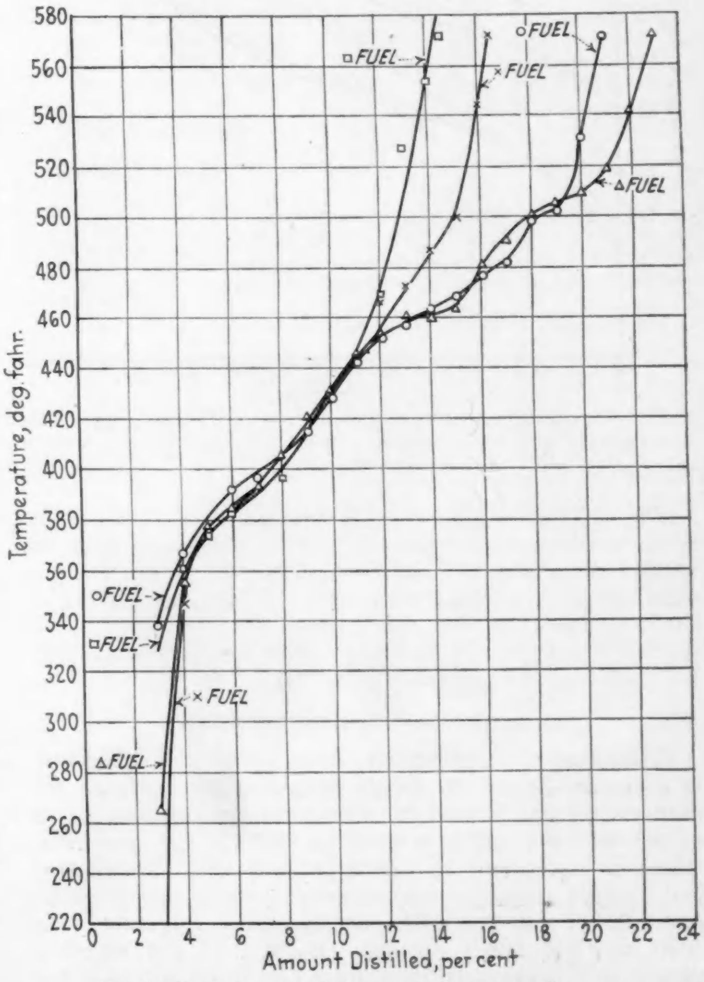

FIG. 9—DISTILLATION CURVES FOR COMPOSITE SAMPLES
These Curves Show the Percentages Distilled at Given Vapor-Temperatures from Four Composite Samples Made-Up from Equal Portions of Samples of Diluted Crankcase-Oil Taken Separately from All Cars for Each of the Four Fuels

volatility, at approximately 450 deg. fahr. Inasmuch as the vapor temperatures were carried to the high point, 572 deg. fahr., it is probable that a certain amount of cracking of the oil itself took place toward the end of the runs.

Although the results are not strictly comparable, it is of interest to see that at a temperature of 572 deg. fahr. the mechanical group-averages for the composite samples agree within 1 or 2 per cent of dilution with the numerical group-averages obtained from the separate runs as given in Table 7.

The significance of the close agreement of the four curves of Fig. 9 is not entirely clear. It would seem to indicate that the engines had so treated the diluted oils by driving off certain fuel-fractions as to make the mixtures alike with respect to the dilution and the temperature within the temperature range of the relatively lighter fuel-fractions. It is pointed out that the distillations of Fig. 9 were only extended to the point where all the dilution products should have come over.

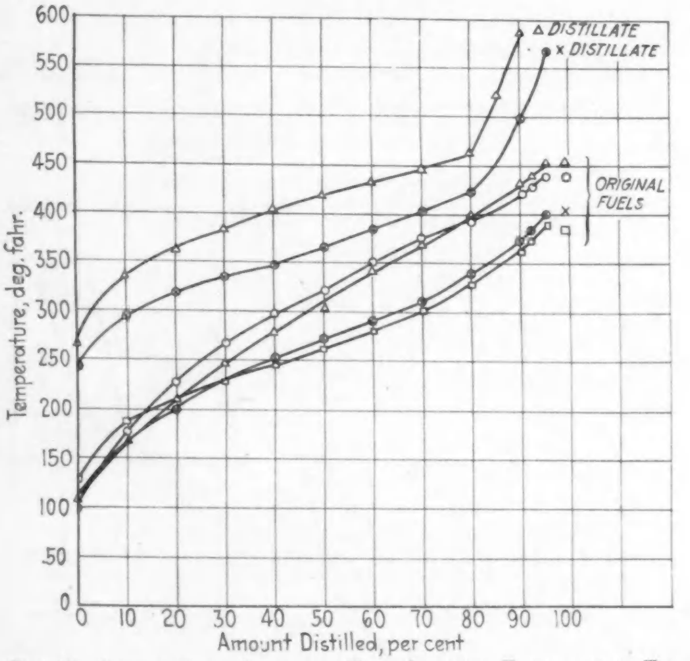

FIG. 10—DISTILLATION CURVES OF FOUR ORIGINAL FUELS AND OF TWO SAMPLES OF DISTILLATE OBTAINED FROM THE DISTILLATION SHOWN IN FIG. 9

The distillates produced by distilling two of the composite samples mentioned above were redistilled with the results shown by the curves of Fig. 10. Here the distillations were carried to dryness. Distillation curves of the original fuels are also plotted for reference. The distillate curves rise abruptly near the end-point temperatures of the original fuels.

CRANKCASE-OIL CONSUMPTION

Crankcase-oil consumption, both actual and apparent, is given in Tables 10 to 13 inclusive; the mileage for each run is also indicated. The computations showed an actual oil-consumption averaging 0.00210 gal. per mile, which is equivalent to 476 miles per gal. The lowest and highest group-average oil-consumptions were 0.00095 and 0.00417 gal. per mile, corresponding respectively to 1050 and 240 miles per gal. Certain of the reported values were obviously inaccurate, so were not included in the averages. The average mileage, neglecting certain of the runs as indicated on the tables, was 196. This grand average is practically the same as the separate averages for the four fuels. Oil-consumption data were not obtainable for cars 37 to 41 inclusive, which accounts for their absence in the tables.

TABLE 10—CRANKCASE-OIL CONSUMPTION WHEN □ FUEL WAS USED IN THE CARS

Car No.	Apparent Oil-Consumption, Gal.[4]	Dilution, Per Cent	Actual Oil-Consumption, Gal.	Miles Covered	Actual Miles per Gal. of Oil	Actual Gal. per Mile
1	0.000	11.4	0.198	141	712	0.00140
2	+0.031	11.5	0.173	147	850	0.00118
3	—0.156	9.0	0.300	189	630	0.00159
4	+0.125	13.5	0.127	102	804	0.00125
Group 1 Average				145		0.00135
5	—0.125	10.0	0.287	193	672	0.00149
6	—0.187	10.0	0.343	130	379	0.00264
7	—0.345	14.4	0.547	274	501	0.00200
8	+0.312	10.0	.....	62[b]	...	....
Group 2 Average				199		0.00204
9	0.000	20.8	0.312	371	1,188	0.00084
10	—0.875	12.5	0.953	369	387	0.00259
11	—0.500	14.0	0.640	134	210	0.00478
12	+0.187	21.5	0.175	121	692	0.00145
Group 3 Average				249		0.00241
13	+0.125	19.5	0.191	412	2,157	0.00047
14	+0.125	10.5	0.046	55	1,195	0.00084
15	—0.187	28.0	0.555	199	358	0.00279
16	0.000	15.0	0.225	278	1,235	0.00081
Group 4 Average				236		0.00123
17	—0.250	18.0	0.475	178	375	0.00267
18	+0.125	9.0	0.021	49	233	0.00043
19	0.000	13.3	0.200	78	390	0.00256
20	0.000	24.0	0.360	117	325	0.00308
Group 5 Average				105		0.00218
21	—1.030	6.5	1.061	690	650	0.00154
22	.....	9.0	.....	288[b]	...	....
23	—0.268	11.5	0.410	153	373	0.00268
24	—0.430	15.4	0.595	449	754	0.00132
25	—0.553	11.0	0.657	298	453	0.00220
26	—0.212	13.0	0.380	220	580	0.00173
Group 6 Average				362		0.00189
27	—0.187	11.0	0.275	212	771	0.00130
28	—0.125	11.2	0.222	180	811	0.00123
29	—0.031	14.0	0.167	112	671	0.00149
30	.....	....	.....	113[b]	...	....
Group 7 Average				168		0.00134
31	—0.062	16.0	0.292	252	864	0.00116
32	0.000	15.3	0.229	257	1,122	0.00089
33	0.000	6.5	0.097	213	2,198	0.00046
34	+0.250	22.0	0.135	186	1,376	0.00073
35	+0.125	....	.....	253[b]	...	....
36	0.000	11.5	0.172	283	1,645	0.00061
Group 8 Average				238		0.00077
Group 9 Average[5]				...		....
42	—1.062	12.5	1.117	586	524	0.00191
43	+0.187	12.1	0.016	186[b]	11,630	0.00009[b]
44	—0.375	18.5	0.582	144	247	0.00404
45	+0.031	16.4	0.220	255	1,159	0.00086
Group 10 Average				328		0.00227
46	+0.156	13.0	0.058	136	2,345	0.00043
47	+0.062	21.7	0.276	161	584	0.00171
48	0.000	13.0	0.195	123	631	0.00158
49	—0.468	12.0	0.592	169	285	0.00350
Group 11 Average				147		0.00181

TABLE 10—CRANKCASE-OIL CONSUMPTION WHEN □ FUEL WAS USED IN CARS (*Concluded*)

Car No.	Apparent Oil-Consumption, Gal.[4]	Dilution, Per Cent	Actual Oil-Consumption, Gal.	Miles Covered	Actual Miles per Gal. of Oil	Actual Gal. per Mile
50	—0.468	14.0	0.578	219	379	0.00264
51	—0.468	9.0	0.539	179	332	0.00301
52	—0.562	18.5	0.690	152	220	0.00454
53	+0.062	13.5	0.115	156	1,356	0.00074
Group 12 Average				176		0.00273
54	—0.216	8.3	0.323	88	272	0.00367
55	+0.027	11.0	0.141	102	724	0.00138
56	—0.266	6.0	0.340	48	141	0.00709
57	—0.418	6.4	0.487	40[b]	82	0.01220[b]
Group 13 Average				79		0.00411
Grand Average				208		0.00194

[4] The plus sign indicates that more oil was removed from the crankcase than was put in at the start; the minus sign has the opposite significance.
[b] Not included in averages.
[5] Oil-consumption data not obtainable for cars Nos. 37-41 inclusive composing this group.

TABLE 11—CRANKCASE-OIL CONSUMPTION WHEN × FUEL WAS USED IN CARS

Car No.	Apparent Oil-Consumption, Gal.[6]	Dilution, Per Cent	Actual Oil-Consumption, Gal.	Miles Covered	Actual Miles per Gal. of Oil	Actual Gal. per Mile
1	+0.031	12.6	0.197	124	630	0.00159
2	—0.125	13.0	0.336	112	334	0.00300
3	0.000	14.5	0.253	136	538	0.00186
4	0.000	15.0	0.262	150	572	0.00175
Group 1 Average				131		0.00205
5	—0.125	9.0	0.271	109	402	0.00249
6	—0.313	10.5	0.463	164	354	0.00282
7	+0.250	11.6	.....	144[c]	...	....
8	.....	....	.....	...	...	....
Group 2 Average				137		0.00266
9	+0.187	22.0	0.183	101	552	0.00181
10	—1.218	18.5	1.271	376	296	0.00338
11	—0.062	15.8	0.290	97	334	0.00299
12	+0.031	12.0	0.152	82	539	0.00185
Group 3 Average				164		0.00251
13	+0.031	35.0	0.505	143	283	0.00353
14	+0.250	14.2	0.000	47[c]	...	....
15	0.000	23.0	.....	114[c]	...	....
16	+0.187	17.0	0.100	144	1,440	0.00069
Group 4 Average				144		0.00211
17	—0.187	17.5	0.417	139	295	0.00300
18	—0.313	19.8	0.547	293	536	0.00187
19	0.000	12.6	0.190	79	416	0.00240
20	+0.062	29.0	0.377	102	271	0.00370
Group 5 Average				153		0.00274
21	—0.883	8.5	0.936	456	487	0.00205
22	.....	10.4	.....	305[c]	...	....
23	—0.408	10.5	0.523	159	304	0.00329
24	—0.385	10.5	0.502	357	712	0.00141
25	—0.350	11.0	0.475	317	668	0.00150
26	.....	9.8	.....	232[c]	...	....
Group 6 Average				322		0.00206
27	+0.375	9.5	.....	154[c]	...	....
28	—0.375	20.0	0.500	173	346	0.00289
29	—0.062	14.5	0.198	101	510	0.00196
30	—0.062	13.5	0.190	77	405	0.00247
Group 7 Average				117		0.00244

TABLE 11—CRANKCASE-OIL CONSUMPTION WHEN × FUEL WAS USED IN CARS (*Concluded*)

Car No.	Apparent Oil-Consumption, Gal.[6]	Dilution, Per Cent	Actual Oil-Consumption, Gal.	Miles Covered	Actual Miles per Gal. of Oil	Actual Gal. per Mile
31	—0.125	18.0	0.372	347	933	0.00107
32	0.000	10.0	0.150	225	1,500	0.00067
33	0.000	12.2	0.182	248	1,363	0.00073
34	+0.375	25.1	0.096	377[c]	3,930	0.00026[c]
35	—0.125	13.0	0.303	254	839	0.00119
36	—0.062	14.0	0.263	290	1,102	0.00091
Group 8 Average				273		0.00091
Group 9 Average[7]				...		....
42	—0.343	12.0	0.482	424	880	0.00114
43	—0.062	17.0	0.307	189	616	0.00162
44	—0.312	14.5	0.485	130	268	0.00373
45	+0.062	16.0	0.187	192	1,026	0.00097
Group 10 Average				234		0.00186
46	+0.093	12.0	0.097	140	1,444	0.00069
47	+0.218	21.4	0.148	130	879	0.00114
48	+0.125	11.5	0.061	133	2,180	0.00046
49	—0.281	13.5	0.446	95	213	0.00470
Group 11 Average				124		0.00175
50	—0.062	10.5	0.187	167	894	0.00112
51	—0.468	12.3	0.565	180	318	0.00314
52	—0.281	17.0	0.446	147	330	0.00307
53	—0.062	12.3	0.208	171	823	0.00122
Group 12 Average				166		0.00214
54	—0.175	13.9	0.359	93	259	0.00386
55	+0.100	10.5	0.068	45	662	0.00151
56	—0.470	14.9	0.624	61[c]	98	0.01020[c]
57	—0.747	10.0	0.822	79[c]	96	0.01040[c]
Group 13 Average				69		0.00268
Grand Average				181		0.00208

[6] The plus sign indicates that more oil was removed from the crankcase than was put in at the start; the minus sign has the opposite significance.
[c] Not included in averages.
[7] Oil consumption data not obtainable for cars Nos. 37-41 inclusive composing this group.

TABLE 12—CRANKCASE-OIL CONSUMPTION WHEN O FUEL WAS USED IN THE CARS

Car No.	Apparent Oil-Consumption, Gal.[8]	Dilution, Per Cent	Actual Oil-Consumption, Gal.	Miles Covered	Actual Miles per Gal. of Oil	Actual Gal. per Mile
1	0.000	11.3	0.197	161	816	0.00122
2	—0.125	19.5	0.441	106	240	0.00416
3	—0.125	15.5	0.377	251	666	0.00150
4	+0.125	15.0	0.156	93	595	0.00168
Group 1 Average				153		0.00214
5	—0.125	8.7	0.266	167	628	0.00159
6	—0.313	24.2	0.660	195	296	0.00338
7	—0.125	29.5	0.603	407	675	0.00148
8	.....	....	.....	...	...	....
Group 2 Average				256		0.00215
9	+0.375	22.3	0.041	125[d]	3,050	0.00033[d]
10	—0.315	27.7	0.686	287	418	0.00239
11	0.000	21.5	0.322	140	435	0.00230
12	+0.500	33.6	0.172	148	860	0.00116
Group 3 Average				192		0.00195
13	+0.250	13.8	.....	152[e]	...	....
14	+0.250	20.8	0.113	64	566	0.00177
15	0.000	13.0	0.195	107	549	0.00182
16	0.000	25.5	0.382	244	639	0.00157
Group 4 Average				138		0.00172

TABLE 12—CRANKCASE-OIL CONSUMPTION WHEN O FUEL WAS USED IN CARS (*Concluded*)

Car No.	Apparent Oil-Consumption, Gal.[8]	Dilution, Per Cent	Actual Oil-Consumption, Gal.	Miles Covered	Actual Miles per Gal. of Oil	Actual Gal. per Mile
17	—0.313	17.5	0.520	119	229	0.00437
18	+0.125	29.0	0.346	108	312	0.00320
19	0.000	19.3	0.290	99	342	0.00293
20	+0.500	42.0	0.340	116	341	0.00293
Group 5 Average				110		0.00336
21	—0.897	14.5	0.985	567	576	0.00174
22	.....	19.7	.....	351[d]	...	....
23	—0.293	15.9	0.485	193	398	0.00251
24	.....	28.0	.....	340[d]	...	....
25	—0.576	26.5	0.821	463	564	0.00178
26	—0.095	22.0	0.403	222	551	0.00182
Group 6 Average				361		0.00196
27	+0.063	22.0	0.170	113	665	0.00150
28	+0.063	48.6	0.455	157	346	0.00290
29	+0.078	29.0	0.235	126	536	0.00186
30	—0.031	22.5	0.250	122	488	0.00205
Group 7 Average				129		0.00208
31	—0.125	22.7	0.437	331	756	0.00132
32	+0.125	28.6	0.340	319	939	0.00107
33	+0.125	19.0	0.183	260	1,420	0.00071
34	+0.080	27.0	0.347	175	505	0.00198
35	—0.063	16.4	0.298	262	880	0.00114
36	+0.375	24.5	0.085	264[d]	3,110	0.00032[d]
Group 8 Average				269		0.00124
Group 9 Average[9]				...		....
42	—1.343	15.0	1.370	857	626	0.00157
43	+0.187	....	.....	258[d]	...	....
44	+0.375	40.5	0.380	146	384	0.00260
45	+0.125	29.5	0.360	286	795	0.00126
Group 10 Average				429		0.00181
46	+0.187	37.3	0.441	89	202	0.00496
47	+0.875	39.5	0.062	93	1,500	0.00067
48	+0.218	18.7	0.102	123	1,210	0.00083
49	—0.218	18.5	0.456	145	318	0.00314
Group 11 Average				112		0.00240
50	0.000	21.5	0.268	141	526	0.00190
51	—0.313	25.0	0.547	232	424	0.00236
52	—0.437	27.0	0.656	198	302	0.00331
53	+0.063	18.0	0.173	192	1,100	0.00090
Group 12 Average				191		0.00212
54	—0.203	17.3	0.427	110	258	0.00388
55	+0.136	21.0	0.208	60	288	0.00347
56	—0.234	10.5	0.367	55	150	0.00667
57	—0.858	21.0	0.993	112	113	0.00886
Group 13 Average				84		0.00572
Grand Average				199		0.00240

[8] The plus sign indicates that more oil was removed from the crankcase than was put in at the start; the minus sign has the opposite significance.
[d] Not included in averages.
[9] Oil-consumption data not obtainable for cars Nos. 37-41 inclusive composing this group.

TABLE 13—CRANKCASE-OIL CONSUMPTION WHEN △ FUEL WAS USED IN CARS

Car No.	Apparent Oil-Consumption, Gal.[10]	Dilution, Per Cent	Actual Oil-Consumption, Gal.	Miles Covered	Actual Miles per Gal. of Oil	Actual Gal. per Mile
1	.....	....	.....	...	...	....
2	0.000	24.5	0.428	192	449	0.00223
3	0.000	14.6	0.255	209	820	0.00125
4	+0.125	19.5	0.240	91	379	0.00264
Group 1 Average				164		0.00204

TABLE 13—CRANKCASE-OIL CONSUMPTION WHEN △ FUEL WAS USED IN CARS (*Continued*)

Car No.	Apparent Oil-Consumption, Gal.[10]	Dilution, Per Cent	Actual Oil-Consumption, Gal.	Miles Covered	Actual Miles per Gal. of Oil	Actual Gal. per Mile
5	—0.031	16.0	0.306	208	680	0.00141
6	—0.125	16.5	0.393	128	326	0.00307
7	+0.250	23.5	0.220	215	978	0.00102
8	+0.313	20.2	0.103	68	660	0.00152
Group 2 Average				155		0.00175
9	+0.125	28.5	0.339	151	445	0.00225
10	—0.250	31.5	0.643	382	594	0.00168
11	+0.125	21.5	0.223	120	538	0.00186
12	+0.750	15.7	.....	126[e]	...	....
Group 3 Average				218		0.00193
13	+0.250	27.0	0.222	303	1,365	0.00073
14	+0.281	20.0	0.075	66	881	0.00114
15	+0.125	14.0	0.102	192	1,883	0.00053
16	+0.313	9.0	.....	142[e]	...	....
Group 4 Average				140		0.00080
17	0.000	22.8	0.342	168	491	0.00532
18	+0.063	22.8	0.293	89	304	0.00329
19	+0.063	21.5	0.273	112	410	0.00244
20	+0.500	36.5	0.230	138	600	0.00167
Group 5 Average				127		0.00318
21	—0.577	20.5	0.766	543	709	0.00141
22	.....	20.0	.....	332[e]	...	....
23	—0.200	24.0	0.512	251	490	0.00204
24	.....	28.5	.....	207[e]	...	....
25	—0.296	26.5	0.615	248	403	0.00248
26	.....	28.0	.....	187[e]	...	....
Group 6 Average				347		0.00198
27	+0.217	26.3	0.102	155	1,520	0.00066
28	—0.187	27.7	0.412	137	333	0.00300
29	+0.196	32.0	0.186	137	737	0.00136
30	—0.375	9.7	0.436	175	401	0.00249
Group 7 Average				151		0.00188
31	+0.031	28.0	0.397	318	802	0.00125
32	+0.125	15.4	0.125	211	1,687	0.00059
33	+0.250	16.0	0.030	205[e]	6,835	0.00015[e]
34	+0.375	32.5	0.235	243	1,034	0.00097
35	0.000	20.0	0.300	305	1,016	0.00098
36	+0.250	25.0	0.187	338	1,807	0.00055
Group 8 Average				283		0.00087
Group 9 Average[1]				...		....
42	—0.468	26.0	0.736	756	1,028	0.00097
43	+0.187	25.5	0.242	151	624	0.00160
44	—0.031	25.6	0.407	130	319	0.00313
45	+0.281	25.7	0.176	155	881	0.00114
Group 10 Average				298		0.00171
46	+0.500	25.5	0.010	105[e]	10,500	0.00009[e]
47	+0.375	30.5	0.197	183	930	0.00108
48	+0.218	23.0	0.176	124	704	0.00142
49	—0.156	19.0	0.411	173	421	0.00238
Group 11 Average				160		0.00163
50	—0.062	19.5	0.293	154	526	0.00190
51	—0.406	21.0	0.583	186	318	0.00313
52	—0.281	26.5	0.537	148	276	0.00363
53	+0.125	19.5	0.143	142	994	0.00101
Group 12 Average				157		0.00242

TABLE 13—CRANKCASE-OIL CONSUMPTION WHEN △ FUEL WAS USED IN CARS (*Concluded*)

Car No.	Apparent Oil-Consumption, Gal.[10]	Dilution, Per Cent	Actual Oil-Consumption, Gal.	Miles Covered	Actual Miles per Gal. of Oil	Actual Gal. per Mile
54	—0.061	15.7	0.287	53	185	0.00542
55	+0.095	19.0	0.208	141	678	0.00147
56	—0.573	8.0	0.647	115	178	0.00562
57	—0.772	12.5	0.863	65[e]	75	0.01330[e]
Group 13 Average				103		0.00417
Grand Average				197		0.00199

[10] The plus sign indicates that more oil was removed from the crankcase than was put in at the start; the minus sign has the opposite significance.

[e] Not included in averages.

[11] Oil-consumption data not obtainable for cars Nos. 37-41 inclusive composing this group.

SUMMARY

The winter tests showed a slight increase in average fuel consumption for the increase of 55 deg. fahr. in the 90-per cent point of the distillation curves. This difference in economy is unimportant when compared with the estimated difference in the possible production of the two extreme fuels from a given quantity of crude oil.

Drivers agreed that the more-volatile fuels were superior as regards starting and general performance. The preference corresponded to the relative volatility arrangement between the 14 and the 20-per cent points of the distillation curves. Particular interest is attached to this because of the relatively small temperature differences existing within this range.

Details concerning the above conclusions are to be found in the report published in THE JOURNAL[12] for July 1923.

Less-volatile fuels gave greater dilution. Similar fuels gave greater dilution in winter than in summer.

Within the mileage range covered by the tests, dilution appears to reach an approximate equilibrium after comparatively short runs.

Actual crankcase-oil consumption for all the tests averaged 0.00210 gal. per mile which is equivalent to 476 miles per gal.

APPENDIX

One of the cooperating companies conducted, in addition to the regular tests described in this and the previous report, a set of parallel runs with both a commercial gasoline and a special winter fuel marketed in the locality. Table 14 gives a comparison of fuel characteristics and other points of interest between the regular test fuels, the special winter fuel *Y* and the ordinary commercial fuel *Z*.

TABLE 14—COMPARISON BETWEEN SPECIAL WINTER FUEL AND REGULAR TEST FUELS

Fuels	□	X	0	△	Y Winter	Z
Initial Point, deg. fahr.	126	112	100	104	106	106
20-Per Cent Point, deg. fahr.	210	200	228	210	187	207
90-Per Cent Point, deg. fahr.	362	375	420	430	358	383
Average Dilution, per cent					8.8	10.5
Miles per Gal. of Gasoline					15.4	13.4
Average Run, miles					104	97

It is seen that the winter fuel *Y* had a 90-per cent-distillation temperature only 4 deg. fahr. lower than that of □, the lowest of the regular group; while the 20-per cent point of the *Y* fuel was 13 deg. fahr. lower than that of *X*, the lowest of the regular group at that point. The ordinary commercial grade of gasoline had distillation characteristics that were intermediate among those of the test group.

Although the runs with *Y* fuel averaged about 33 per cent greater, the dilution was practically the same as for □ fuel, the lowest of the group. The special fuel showed an increase in the miles per gal. of 16 per cent over *O* fuel, the next best of the group.

The company that conducted these reference tests made observations as to the number of cars used at different times by the employes; those who did not use their cars walked to their work. It was concluded from these observations that for every 10-deg. fahr. drop in the temperature below 70 deg. fahr. 15 per cent fewer cars were used. While these figures do not tell the whole story, they are nevertheless indicative of the influence of temperature on the use of cars.

Drivers were reported to have shown great preference for the winter fuel, 55 per cent of all cars in the shop having adopted this particular fuel and 17 per cent having adopted other brands of high-test fuel within 2 months after their appearance. On a day when the temperature was minus 22 deg. fahr. 12 per cent of the cars, all using *Y* fuel, were present. In previous years before the special fuel became available, no cars were present when the temperature dropped below minus 10 deg. fahr. A later survey showed that a much greater number were using it.

[12] See THE JOURNAL, July, 1923, p. 90.

MOTORIZED AMERICA

AT the present time 15,000,000 motor vehicles are in use in the United States and if all of them were to be concentrated upon the Lincoln Highway from the banks of the Hudson to the Golden Gate, that famous transcontinental road would have to be widened to a paved width of 120 ft. so that 15 cars could stand abreast. The aggregate mileage of American motor vehicles based on what is considered an average amount of running equals a round-trip to the sun every 21 hr. and the quantity of gasoline necessary for this annual mileage exceeded 6,000,000,000 gal, in 1922. The passenger-miles covered by motor cars in the United States is reckoned as three times that of the railroads and, according to one statistician, the American people are today spending more for automotive transportation than for any other thing except clothing and meats. America is preeminently the home of the motor car for the reason that in this Country wealth is much more evenly distributed than elsewhere and more people can own cars. Thus, 11 out of every 13 motor vehicles in the world are in America. There are more motor vehicles in the four States of New York, Pennsylvania, New Jersey and Maryland than there are in all the rest of the world outside of the United States, the registration in these States on Dec. 31, 1923, being 2,903,377 vehicles.—W. B. Showalter in *National Geographic Magazine*.

Problems of Motor-Vehicle Electrical-Equipment Maintenance

By P. J. DURHAM[1]

DAYTON SERVICE MEETING PAPER

FACTS regarding present obstacles to proper maintenance of automotive electrical-equipment are related to make clear how imperative it is that such faults be corrected. The main problem of the automotive field electrician is stated; it is to get the job done right so that it will *stay* right, to do it soon enough to please the customer, to keep the cost low and to make a profit. But the difficulties attendant upon its solution are numerous.

A discussion of these difficulties is presented under the headings: Diagnosis, head-lamps, accessibility, terminal connections, fuses, wiring color-code, storage-battery, starting motor and generator. Many instances are cited wherein faulty design, cheap construction, lack of accessibility and failure to consider maintenance requirements militate seriously against satisfactory accomplishment of electrical-equipment up-keep by the field engineer. All such cases must be minimized and many can be eliminated.

IN gathering material for this paper, I was struck with the seriousness of certain conditions that should make the subject a matter of deep significance to those who, if not interested in service, are interested in the building and selling of automobiles. Repairs necessary after long and useful service, or on apparatus accidentally broken but made of good materials with good workmanship, are comparatively simple to handle. It is frequent repairs that are necessary while the car is yet comparatively new that annoy the owner and worry the repair-man most. Under such circumstances there appears a grisly specter, cheapness, which shows the repairman how dangerously close to the limits of practicality some apparatus is made. This establishes in the owner's mind the thought that some of the equipment on his new car is low-grade, inefficient and impractical, or that it has not been installed in a workmanlike manner. Some dealers admit frankly to owners that "minor details" are not given much consideration in "that" grade of car and that they must put up with some annoyances when they purchase popular-priced cars of large production. The method of minimizing the amount of necessary repairs through better designing, materials and factory workmanship is not within the province of this paper. But I hope that the facts I bring to you will make clear wherein improvement is vital. The expenditure of a few cents, or at most a few dollars, per car, when it will save the owner many dollars during the first year of service, is worthy of consideration. The main problem of the automotive field electrician is to get the job done right, to get it done so that it will *stay* right; to get it done soon enough to please the customer; to keep down the cost of the job; and, not by any means least important, to make a profit.

DIAGNOSIS AND REPAIR

Most of you men would hesitate, in spite of your long experience and intimate familiarity with the automobile, to attempt to locate electrical faults. I want to establish the thought that, while in a few years thousands of men in the industry have learned *something* about the electrical system, much relating to it is beyond the grasp of the average mechanic, considerable that requires long and painstaking study. The magneto has been with us for 20 years, yet comparatively few men are capable of repairing it properly. There is a scarcity of good automotive electricians.

There are other factors. A great many motor-driven horns, as well as vibrators, are made so flimsily and cheaply that they are as difficult to repair as a 10-cent mechanical toy. In one case the cover is spun over so that one needs a can-opener to open it. Of course, there are good horns and horn buttons. The time consumed in trying to get a flimsily made horn to operate frequently involves a labor cost greater than the car builder pays for a complete new horn; though it may not exceed what the new owner would pay for a replacement.

HEAD-LAMPS

Head-lamp doors can be removed after a car has been washed or been out in the rain a few times but not without a struggle. Then the reflector falls out, the inside connecting wire breaks and, before the 30-cent bulb is installed, an hour has been used in getting a humpty-dumpty lamp together again. Then let us try to adjust the lamp so that it will give good and legal driving-light. We find frequently that the focusing device is rusted and breaks when we touch it; or, that it is stuck fast, or was not made to be adjusted. Having overcome that difficulty, we find that the reflector has ceased to be, or never was, a real reflector. And the costly remedy is to buy complete new lamps, if obtainable.

In many cases no adequate provision is made to keep the lens from rotating in the lamp door; or for adjusting the aim of the lamp so that the light will be on the road and not on the treetops. After surmounting these many obstacles, in a valiant effort to do a good repair job, the car is driven over a bit of rough road and the lamp is again out of adjustment due to one of its faults of construction.

ACCESSIBILITY

The problem would be much less formidable if accessibility were more a fact than a mere advertising slogan. The front of the lighting and ignition switch is accessible, of course; but no repairs to the front are required. If you can visualize the job of tightening the connections at the back, or of examining the connections to see if they are tight, you have a picture of an electrician who is a contortionist with eyes in his fingertips. In some cases the entire switch can be detached from the cowl-board and brought carefully forward with the wires still attached, but this involves too much work merely to examine the connections. Many switch-terminal screws are so small that it is very difficult to attach the wires. As a result, they quickly become loosened. It is ludicrous

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to see a husky mechanic, lying under a cowl-board, trying with his No. 9 hands to attach a wire under the head of a 6-32 screw. But, it is not funny when an owner objects to a large labor-charge for electrical service-work that is inescapably long because overgrown watch-screws must be fiddled with. It is very bad.

Terminal Connections

I hope that the "powers-that-be" will give us better switch-terminals, with at least No. 12 screws having generous-sized heads under which wires can be fastened and expected to stay fastened. The screws should be made of brass, not iron. Iron machine-screws have no proper place in an electrical circuit of any apparatus because of their liability to rust and corrosion.

Loose ammeter-terminals have cost the car-owner much money. The damage due to increased voltage in the charging circuit may be very extensive. The first consequence may be damage to the ammeter itself from the heat generated at the loose connection. The electric bulbs burn-out, and ignition points arc and pit and sometimes become welded together. Ignition coils also are burned-out. Regular contacts become pitted and armature and field windings are heated to a damaging extent, drying-up the oil in, and causing rapid wear of, the bearings.

The fact that connections are frequently found loose at switches and ammeters of cars that have been in service only a short time shows that difficulties of the kinds mentioned were experienced in the assembly work at the factories. Surely this is evidence of the need for more positive terminals. Incidentally, the equipment manufacturers have repeatedly borne the expense of reconditioning generators within the 90-day warranty period, although the real cause of the damage was flimsy connections in the charging lines for which they were not responsible.

Fuses

In the majority of cases, both the fuses and fuse clips are too small and flimsy to be practical. The ⅝ and the 1 3/16-in. long fuses, with the clips that hold them, have given considerable trouble because of the poor contact between the fuse and its clip. A little dust or corrosion will prevent contact. In some cases, where a 20-amp. fuse is used, the heat generated in the fuse causes the clip to lose its temper and become useless. In the case of clips riveted to the back of a lighting switch or to a fuse-block, it is necessary frequently to install a complete new unit if one of the little clips is bad. Under present circumstances, it is a task to remove the small fuses. They should be made and clipped so that they can be removed readily by the thumb and a finger, instead of involving the use of a screwdriver or a buttonhook.

Wiring

The wiring of a chassis seems to have become a lost art, at least in the case of popular-priced cars. Wires are simply run from "here to there," usually by direct route, without regard to function, or liability to damage or breakage of wires in the normal use of the car. It is customary to run a wire from the generator terminal direct to the ammeter and then to the starting-switch, the nearest point to pick-up the battery, the return by ground, the most important circuit in the system, completing the charging circuit. These wires rarely are secured at any place except at the various terminals which are already overworked in carrying the electrical current, without the additional job of supporting a swinging cable or holding it against accidental pull. Frequently it is found that the insulation has been chafed through as the result of rubbing contact with other chassis parts. In one instance the live starting-cable from the battery is looped up with a sharp piece of tin, fastened to the transmission case. In a number of cases the tin loop has cut through the cable, causing a short-circuit that discharged the battery and also harmed the generator operation.

Many tail-lamp wires run the entire length of the chassis frame without being fastened at any intermediate point and frequently become grounded or short-circuited by being rubbed or pinched. The ground connections of single-wire installations are often made more mechanically than in a manner to establish good electrical connections. In too many cases the main battery-cable is improperly grounded. The lug of this cable is sometimes attached to the frame with an iron rivet. Unfortunately, due to vibration, corrosion and rust, this does not give a good permanent electrical connection, and it becomes necessary to cut the rivet out with a cold-chisel and hammer, the mechanic lying under the car to do this.

Incidentally, paint on the chassis is not a good conductor of electricity. Tail-lamps are notoriously poorly grounded; subjected to more vibration than other parts of the car, they suffer from bad connections. A roadside remedy to eliminate a ground is to drive a few nails between the fender and its supporting iron or between the fender and the frame or the body. Poor ground connections are very common also in head-lamp wiring. They are sometimes very difficult to find.

Color Code for Wiring

The suggestion has been made repeatedly that a standard code of colors be adopted for the wiring of the different circuits of the electrical system. This method was followed 12 or 15 years ago in a certain ignition system. A standard system, if generally adopted, would shorten amazingly the length of time necessary to trace or test the various wire circuits. All who have tried to follow a circuit in a maze of wires under the average cowl-board appreciate this. Locating wiring troubles is generally not an easy task. Sometimes, to do the job right, it is necessary to remove and re-install most of the cables.

Storage-Batteries

The storage-battery has probably been the cause of more grief to the service-man than any other part of the car since cars were first built. The owner vents his displeasure on the "mysterious black box;" the cussing that tires used to get is now directed whole-heartedly to the battery. The first obstacle seems to be the terminals. It is not easy to ascertain whether they are electrically "tight" or to predict how long they will stay so. Loose and corroded battery-terminals have caused much trouble. The average battery-station seems to have difficulty in connecting the terminals properly. A better terminal of generous size, easy to clean and positive in contact would aid greatly in "getting the job done right."

Accessibility is important in securing better service from the battery. If it is a hard and dirty job to get at and test a battery, hard and dirty mechanics will probably be assigned to the job.

It may mean something to a car-builder to have his batteries custom-tailored to fit a particular model of car. It may satisfy something in somebody if around this special battery is wrapped a snug container that will

accommodate no other type of battery. But this practice creates a serious condition in service work. Numerous types of batteries have been designed with innumerable combinations of terminal arrangement. The result is that stocking a battery service-station involves a considerable investment. There is no justification for criticism if a battery-station happens not to have in stock a particular type of battery or a delay is occasioned in changing terminal positions. Keeping stocks of slow-moving special batteries is hazardous. Turnover is what constitutes profitable business. There is not a "handspring" in a whole carload of special batteries. Some consideration must be given to making the battery container at least a little larger. Nothing but good can come of replacing with a larger battery the original battery of a car, especially if the latter is of a size that cannot be obtained readily. If the owner is willing to pay for a better battery than was in the car when he got it, he should not be penalized further by having to pay for a new container to hold it.

Motor and Generator

The starting motor is probably the best behaved unit of the electrical system. Repair work on it is required mostly by damage due to the kickback of the engine. With the starting-switch, however, considerable trouble is experienced. Again, the difficulty of getting the job done right is due largely to inaccessibility of the terminals and the mounting bolts. Good electrical contact at the starting-switch terminals is essential in the proper maintenance of the starting circuit as well as other circuits.

When the generator is at fault, we encounter probably the most difficult phase of electrical service-work. This unit is called upon to do more than any other and it is least understood by mechanics generally. Considerable time is consumed in reconditioning the generator, this meaning in most cases that the car must remain idle. Idleness is a most annoying thing in a car. It is more irksome to the owner than the damage itself. A steadily increasing number of cars that cannot be operated without the generator are being built. In many cases the generator drive involves the ignition. Frequently the generator shaft is used to drive oil-pumps, water-pumps and fans. Sometimes its driving sprocket is linked with the camshaft drive.

The form of the generator has been changed so many times to accommodate the whims of good customers that we have in service a great variety of shapes and sizes and characteristics. This hinders greatly, if it does not make utterly impossible, the temporary replacement of a generator that should stay in the shop for repair. The generator is the most expensive of all the electrical units. This also is a deterring factor in the supplying of a rental or loan unit, because not only is there the possibility of dishonesty on the part of the car-owner, but there is the hazard that the generator will suffer serious damage during the rental period, due to faults in other parts of a car's electrical system. The investment in generators needed in general rental practice is a serious matter. Except in cases of minor adjustment, the generator must be removed for bench tests and repairs. In some cases removing a generator is a simple matter, but as a rule the ignition distributor is attached to the generator.

On eight-cylinder jobs the carbureter and the manifolds must be detached. In other cases water-pumps must be removed. This, of course, means a higher labor charge. The labor charge for installation is frequently many times that for the bench repair of the generator.

The Automotive Electrician

The automotive electrician must be a good automobile mechanic also. He must in some cases dismantle the radiator and the lamps, remove the engine bolts, disconnect the transmission, loosen all the manifolds and jack-up the engine, to remove the timing-gear cover that conceals a little cotter-pin which *holds the generator in place*. The "king-pin" of all the jobs is the belt-driven generator, with ignition device mounted on it driven by a concealed shaft. When the position of the generator is adjusted to tighten the belt, the generator operates well enough, but when the owner hits a good bump on the road, the ignition timer becomes disconnected and the car is stalled. The electrical man learns in time that he should have cut a piece out of the belt or replaced it with a new one. But there is nothing to warn him that he is likely to be made responsible for the trouble mentioned.

It is rarely practicable to replace worn brushes while the generator is on the car. Worn brushes mean carbon and copper dust inside the generator, in the bearings, the brush rigging and other parts including the slots between the commutator bars of the armature, this being likely to cause short-circuits or grounds and to increase the wear of the bushings.

Worn brushes also indicate worn commutators, requiring the latter to be turned in a lathe to insure efficient operation. Electrical tests are necessary on the armature, the fields, the brush rigging and other insulated parts to locate grounds, "opens" or "shorts," or to make sure that none of these exists. These tests cannot be made while the generator is assembled, and it is not safe to pass a generator as O. K. unless its performance is up to its maker's specifications. A very light ground, short, or intermittent open may not prevent the generator from generating some current, but these minor faults must be located and corrected. They rarely or never correct themselves; usually they get worse.

Generator bearings require close scrutiny and the repair-man's best attention. They are the only support of the heavy and rapidly rotating armature that is separated from the iron pole-shoes by a gap measured in thousandths of an inch. At best, the life of the bearings ends after only a few thousandths of wear. Then the armature starts to rub on the pole-shoes. Plain bearings, when replaced, must be carefully aligned and reamed to a perfect fit.

We must also watch very closely the lubrication of the bearings, and adjust the oil-retaining washers carefully. The natural propensity of the generator is to become heated when it is charging the battery. The heat and the speed quickly consume the lubricant. If too much oil is used and permitted to get into the generator and mix with the brush carbon-dust, the brushes will stick, and minor shorts and grounds frequently develop.

Conclusion

A class of field men representing the various equipment manufacturers have become skilled in all this work. They have rendered service to the automotive industry and established for themselves a definite place in it. In the name of better service to the car-owner, I ask for closer cooperation between them and the others interested in maintenance problems. The facts I have brought to you do not indicate the faults of any particular make of car or electrical unit, but have been gathered at random from a varied experience. Some of the problems I have touched on affect all makes of car. Others apply to only a few.

Wood for Automobile Bodies

By Arthur T. Upson[1] and Leyden N. Ericksen[2]

Annual Meeting Paper

Illustrated with Charts

SHORTAGE of the most desirable kinds of wood for automobile-body purposes has necessitated the substitution of second-choice woods having the essential required properties and the buying of stock for body parts in cut-up dimensions that conform in size with those now produced in the cutting-room. An investigation by the United States Forest Products Laboratory as to the species, kinds, grades, sizes and amounts used by the automotive industry shows that maple and elm comprise over one-half the total amount used and that ash and gum constitute one-half of the remainder. Although the quantity of ash used has not decreased, the increase in the production of medium and low-priced cars in the last few years has caused a proportional increase in the demand for maple and elm. Classifying cars for purposes of analysis into four groups, small, medium, medium-large and large, the investigators found that the woods most used in small cars are hard and soft maple, elm, birch, beech, oak, gum and pine; that maple, elm and birch are used extensively in bodies of the medium and medium-large classes; and that ash predominates in the large cars, with hard maple as an alternative choice. Fifty-one per cent of the running-boards are made of pine, and 17 per cent are made of sound wormy oak. Oak, ash and elm are used for top-bows in the proportion of 92, 7 and 1. The grade of lumber used in bodies is very high, 40 per cent being firsts and seconds, and 49 per cent No. 1 common and selects. The problem of eliminating light or brash ash is important and, while there are no visual means by which tough and brash ash can be separated, the factors that afford a fairly reliable criterion of strength and toughness are density, rate of growth, proportion of summerwood and the original position of the wood in the tree. Seasoned ash that has good weight and is sound will have strength. Unseasoned ash, on the other hand, cannot be judged by weight.

Little or no uniformity in size of corresponding parts was found among the various makes of body, although the majority fall within very narrow limits. Charts have been prepared showing the range and grouping of the sizes of several of the main body parts, such as the body and door pillars of closed bodies, the main side sills, the side roof-rails, the front and rear roof-rails and the rear belt-rails. The stock used in the larger bodies is of very high quality; in open bodies a few small defects are allowed; in smaller and lighter bodies the requirements are not so severe, a mixture of woods is used, and some defects, such as small sound knots, are allowed in soft maple, elm, and gum, considerable amounts of stain and dote are admitted. When the requirements are not exacting it would be possible to utilize sound low-grades; the use of clear stock where sound stock is sufficient introduces unwarranted expense and wastes material that might serve higher purposes. As the waste in cutting ranges from 20 to 50 per cent, it is evident that careful work at the saws may result in considerable saving. Other ways in which saving may be effected are the gluing-up of stock to get required sizes and a more general use of ready-cut small-dimension stock. As automobile builders are much interested in finding woods that may be substituted for those now in use, a table is given showing the specific gravity, strength, stiffness, shock-resisting ability and hardness of the principal species as compared with those of forest-grown white ash; and the advantages and disadvantages of first and second-growth timber, and such woods as ash, hard and soft maple, rock and white elm, birch, red and sap gum, oak and the softwoods are discussed.

WOOD has held a most important place in the vehicle industry from the earliest times. Its consumption vastly increased with the phenomenal growth of the automobile industry, and as a result the shortage of the kinds and grades of lumber desired for automobile-body purposes soon began to be felt. We have now reached a stage where it has become next to impossible to obtain lumber of the most desired kinds and quality, either because of actual scarcity or because of exorbitant prices that are prohibitive in their effect.

Manufacturers can meet such conditions by several means. Substitution of second-choice woods having the essential required properties offers one solution, and to a considerable extent this has already taken place. Another method of meeting the shortage, and one that is used at present by some companies, is the buying of stock for body parts in cut-up dimensions that conform to the sizes of parts now produced by the saws in the cutting-rooms. To further both these schemes as much as possible, the United States Forest Products Laboratory, in cooperation with the Hardwood Lumber Standardization Subdivision of the Passenger-Car Body Division of the Society, in the summer of 1923 made a survey to determine to what extent the standardization of sizes between the same parts of different makes of automobile bodies prevailed, to study the possibility of further standardization, to ascertain the kinds and grades of lumber being used, and the quality of stock required in the various body parts, and to elicit the views of builders as to the suitability of various woods for such parts. The method of survey consisted in personal visits to more than 40 body plants and in sending letters to others. The success was such that detailed information was obtained from plants representing 95 per cent of the total wood consumption of the industry.

General Classification of the Woods Used

Table 1 shows the consumption of the different species in percentages of the total of 468,000,000 ft. reported by the National Automobile Chamber of Commerce as having been used for bodies in 1922.

The miscellaneous group includes beech, cherry, cottonwood, cypress, hackberry, hemlock, hickory, magnolia, mahogany, pine, spruce, sycamore and walnut. Some of these species are picked up in odd lots and are not in regular use.

The figures show that ash, which has generally been considered the best of the woods for automobile-body construction, has already been surpassed by maple and elm in the quantity consumed. This does not mean that

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TABLE 1—COMPARATIVE CONSUMPTION OF WOODS IN RELATION TO THE TOTAL AMOUNT CONSUMED

Species	Per Cent
Maple	30.1
Elm	22.1
Ash	16.4
Gum	11.9
Oak	7.7
Birch	6.6
Basswood	0.7
Yellow Poplar	0.3
Chestnut	0.2
Miscellaneous	4.0
	100.0

the actual consumption of ash has decreased, but rather that the enormous production of medium and low-priced automobiles in the last few years has caused a proportional lumber demand that hard and soft maple and elm have to a large extent filled. It will be noted that maple, elm, ash, gum, oak and birch are the six woods used in considerable amounts, and together comprise 94.8 per cent of the consumption, leaving only 5.2 per cent to the 16 other species.

To establish a basis on which their wood requirements could be compared, four general sizes of bodies were designated. No fine distinctions were attempted, the division being for working purposes only. The sizes or classes, with examples of the makes included, are as follows:

Small.—Overland, Maxwell, Chevrolet
Medium.—Hupmobile, Durant, Studebaker Light-Six
Medium-Large.—Buick Six, Franklin, Reo
Large.—Cadillac, Packard, Lincoln

An analysis of the cutting bills of 60 separate jobs shows that practically no ash is specified in the small and medium-sized classes of bodies, nor is it specified for open bodies in the medium-large class. For closed bodies of the latter class, however, some ash in mixture with other woods is called for. For bodies of the large class the greatest amounts of ash are required; in some open bodies of this class other woods are admitted, but in closed-body construction ash is used almost exclusively.

Several hardwoods and softwoods are designated for use in bodies of the small class. Among them are hard and soft maple, elm, birch, beech, oak, gum and pine. Some cutting bills merely specify "hardwood" and allow a choice of any of those named. It was found to be the opinion of builders that any of the hardwoods would fulfill the requirements necessary in bodies of this general class and that the choice depended largely upon availability and price.

Maple, elm and birch are used extensively in bodies of the medium and medium-large classes. Some ash is specified in closed bodies of the medium-large class and a very small quantity in closed bodies of the medium size. The different woods are used interchangeably in most cases, oak also appearing to a small extent for main body parts.

Passing to the large class, we find the requirements for bodies more severe. The bodies are heavier. More care is required in their construction. Because price competition in machines of this class is not so keen as among lower-priced cars, appearance and workmanship can be given more consideration. Ash is the wood generally preferred, and it predominates in construction. Some builders use it exclusively, although others recognize the fact that very good results can be obtained with other woods also and are specifying hard maple as an alternative. In open bodies of this class considerable quantities of maple are used. On the other hand, the bodies of some high-priced motor-cars that are produced in small quantities are built entirely of ash.

Woods Used for Running-Boards and Top-Bows

Returns from a special questionnaire regarding the kinds of woods used for running-boards and top-bows afforded some interesting information. A number of different woods are specified for running-board use. In Table 2 the consumption of each wood is compared with the total amount reported.

TABLE 2—COMPARATIVE CONSUMPTION OF WOODS FOR RUNNING-BOARD USE

Species	Per Cent
Pine	51.0
Sound Wormy Oak	17.0
Spruce	9.2
Maple	8.3
Chestnut	5.7
Ash	4.5
Cottonwood	1.3
Cypress	1.2
Fir	1.0
Port Orford Cedar	0.5
Miscellaneous	0.3
	100.0

Of the reported consumption 80 per cent was purchased as lumber and 20 per cent was cut to size at the mill before shipment. As is well known, a considerable number of companies are using metal instead of wood for running-boards.

The conditions encountered by wood in this use are very severe. Aside from the obvious wear, tear, shock and stress imposed, a more important factor is the extreme variation in moisture to which the lower surface of the board is subject. Conditions affecting the upper and lower surfaces are essentially different. Because car builders have not always realized the extent to which wood is affected by moisture differences, considerable trouble has been experienced with running-boards' warping and cupping. Although the difficulty is not limited to any particular species, some woods change their shape more than others under the same moisture changes; and it should be perfectly obvious that those which shrink and swell comparatively little would suit the purpose better. The real trouble, however, is more probably due to the condition of the wood at the time of its manufacture and to the changes in the moisture-content that take place after the running-boards go into service. If the stock has not been properly seasoned, stresses may be present that, after the board has been machined, may be relieved to a certain extent and cause warping or cupping. If stock is dried to a moisture-content that is too high or too low, or if the moisture is unevenly distributed, subsequent changes will cause swelling or shrinking. Moisture-contents of from 8 to 10 per cent should give good results. A considerable amount of the trouble caused by the alternate wetting and drying-out of the lower surfaces could be avoided by the use of effective moisture-resisting coatings.

Oak, ash and elm, the only woods reported as being used in top-bows for open cars, are used in the following proportions: Oak, 92 per cent; ash, 7 per cent; elm, 1 per cent. A good grade of lumber is necessary to provide the clear lengths required, and the wood must be capable of taking a severe bend and of holding the resulting form.

Grades of Lumber Used

The lumber used for automobile-body purposes is of very high quality. From detailed information obtained it was computed that about 40.0 per cent of the material is firsts and seconds, 48.0 per cent No. 1 common and selects and 10.5 per cent Nos. 2 and 3 common. The remainder, or 1.5 per cent, consists of softwoods. A comparison of these figures with returns from other industries shows that a higher grade of lumber is used in automobile-body construction than in any of the other major wood-using industries.

The problem of eliminating light or brash ash is an important one from the viewpoint of the body-builder. Existing grading rules have no provisions by which such material can be sorted out from the denser and tougher stock. To obtain the material desired, buyers frequently specify "tough-textured" ash; but no definite criterion for the selection of this class has been established. Material from the lower cuts of swell-butted trees growing on swampy lands is very often light in weight and, despite the fact that it may show a medium or rapid rate of growth and a large percentage of summerwood, is soft and weak. In general, brash material is the result of growing conditions rather than of species, and ash grown on drier uplands is likely to contain less poor material. Brash or weak ash is not confined entirely to wood of a low specific-gravity; occasionally, material of good weight is found to be very weak.

Although there is no visual means by which tough and brash ash may be separated, there are several factors which, taken together, afford a fairly reliable criterion of strength and toughness. These are

(1) *Density.*—Of two pieces of the same size and containing the same amount of moisture, the heavier will ordinarily have the better strength properties

(2) *Rate of Growth.*—Exclusive of light-weight material, ash that shows a medium or a rapid rate of growth, that is, has fairly wide annual rings, usually has the best strength properties. This rule, however, has exceptions; some wide-ringed material may be brash, and some narrow-ringed material tough

(3) *Proportion of Summerwood.*—The inner portion of each annual ring, known as the springwood, is made up of thin-walled fibers and large open pores. The outer portion, commonly called summerwood, is composed of fibers having thicker walls and fewer small pores. Since the strength varies with the amount of wood substance present per unit of volume, wood containing a relatively large amount of summerwood will usually be strong and tough. This principle does not always hold literally true for ash. Much light ash, though showing wide rings and a large proportion of summerwood, is brash

(4) *Position in the Tree.*—Material from swelled butts of trees growing in swampy locations is likely to be light and weak. Material from the upper portions of such trees and ash grown on uplands are usually of good weight and strength. A selection according to density would normally exclude lightweight butt stock

In general, if seasoned ash is of good weight and is sound, it will have good strength properties. The quality of unseasoned ash lumber, on the other hand, cannot be judged by weight. If the annual rings are fairly wide, the summerwood hard and the wood sound, it is likely to be tough and strong. Seasoned ash of light weight should be avoided when strength and toughness are important, and unseasoned ash with very narrow rings, or with wide rings and spongy summerwood, is likely to be brash and should be carefully inspected.

A number of body-builders send inspectors to loading-points to inspect the ash and sort out all material that seems to be light in handling. In this way they have reduced the proportion of light brash ash in shipments to a very small percentage.

Present Status of Body-Part Size Standardization

An analysis of these sizes of body parts taken from 43 different cutting bills in the 1923 survey showed little or no uniformity in size among the corresponding parts in the various makes of body. In a number of parts, however, some duplication of sizes exists, and the majority fall within rather narrow limits. The charts herewith show the range and groupings of the sizes of several of the main body parts. Fig. 1 refers to the body and the door pillars of closed bodies, Fig. 2 to the main side-sills and the side roof-rails and Fig. 3 illustrates the size variations in the front and the rear roof-rails and the rear belt-rails. In these charts the lengths of the particular body parts under consideration are plotted vertically, the widths horizontally to the left, and the thicknesses horizontally to the right of the vertical lines on which the lengths are plotted. Points on the horizontal lines indicate that a number of thicknesses and

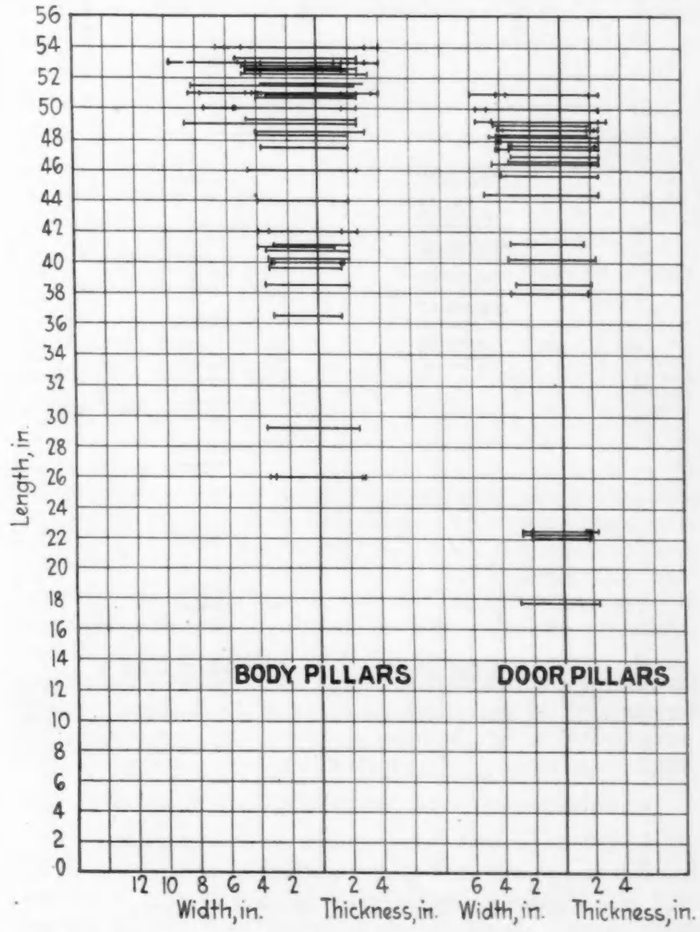

Fig. 1—Variations in the Sizes of Pillars in Closed Automobile Bodies

In Plotting the Chart the Length Is Plotted Vertically, the Width Is Plotted Horizontally to the Left of the Center Ordinate and the Thickness Is Plotted Horizontally to the Right. The Left Half of the Chart Relates to Body Pillars and the Right One to Door Pillars. Closed Body-Pillars Vary in Width from 3 to 9¾ In., with the Majority between 3 and 4 In. The Door Pillars Range from 3 to 6 In. in Width with a Large Number between 3½ and 4½ In.

widths are used with the same lengths. The larger variations in dimensions are in some cases caused by differences in methods of construction. In side-sills the dimensions are for separate pieces and not for assemblies. The sizes shown for side roof-rails include those specified for coupe and for sedan bodies, and naturally the lengths vary greatly. It will be seen that the lengths of body pillars, door pillars, rear belt-rails and front and rear roof-rails overlap to a considerable extent. Many duplications of lengths, and in some instances differences of only a fraction of an inch, were found.

Widths specified for closed-body pillars vary from 3 to 9¾ in. The majority are between 3 and 4 in. wide. In door pillars the widths vary from 3 to 6 in., with a large number between 3½ and 4½ in. Widths of rear belt-rails vary from 2 to 6 in., the majority falling between 2 and 4 in. The widths of front and rear roof-rails are fairly uniform. Except for a few sizes, they all are between 2½ and 4 in. Widths of side-sills and the side roof-rails show greater variations, as might have been expected because of the different methods of building sills and the variations in the wheelbase. Specifications for side roof-rails were taken from stock lists of coupe and sedan bodies, the jobs ranging from the lightest to some of the largest.

[3] The investigation of harwood lumber used in automobile bodies, as undertaken by the Hardwood Lumber Standardization Subdivision of the Passenger-Car Body Division of the Society's Standards Committee, in November, 1922, was delegated in March, 1923, to the Forest Products Laboratory, which is represented on the Subdivision by Mr. Upson. The report when completed will be reviewed and issued in collaboration with the Subdivision.

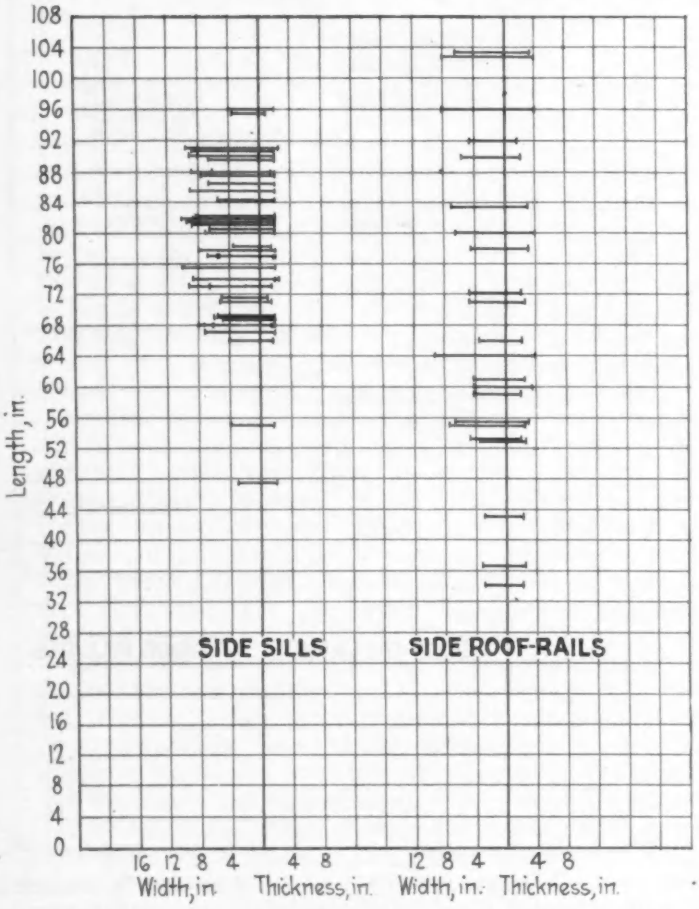

FIG. 2—HOW THE SIDE ROOF-RAILS AND THE SIDE SILLS OF AUTOMOBILE BODIES VARY IN SIZE

The Arrangement of Plotting Is the Same for This Chart as for That Reproduced in Fig. 1; the Length Being Plotted Vertically and the Width and the Thickness Horizontally and to the Left and the Right of the Center Ordinate Respectively. The Wide Variation in the Widths of Both Members Resulting from Different Methods of Construction and Variation in Wheelbase Lengths Should Be Noted. Practically All of the Side Sills in the Left Half of the Chart Are 2 In. Thick, While the Side Roof-Rails at the Right Range from 2 to 4 In. in Thickness

Thicknesses of closed-body and door pillars, of rear belt-rails and of front and rear roof-rails all fall within the same limits. The great majority of these members are between 2 and 3 in. thick; the same thicknesses are specified a number of times. Practically all the side-sills are 2 in. thick, a very few are less than 2 in. in thickness and only two are 2½ in. thick. Side roof-rails were from 2 to 4 in. thick. None was less than 2 in., a number were 2 in. and the remainder varied from 2 to 4 in. in thickness.

From the charts it seems probable that several sizes could be selected that would cover the range of sizes specified for certain body parts such as closed-body pillars, door pillars, rear belt-rails and front and rear roof-rails. The sizes specified for other body parts have also been compiled and grouped, but it was not thought practicable to present them here. They will be submitted to the Subdivision on Hardwood Lumber Standardization of the Passenger-Car Body Division of the Society for use in its standardization program.[3]

The selection, as standards, of sizes that are already specified by a number of automobile builders will make it possible for producers of small-dimension stock to cut pieces of these dimensions at the mill with the assurance that there will be a market for them. At present the manufacture and sale of small-dimension stock is entirely according to order. With the cooperation of consumers, that is, those in the automobile and automobile-body industries, in thus designating sizes they are using in considerable quantities, the producton and sale of this class of material will be put on a sound and permanent basis.

Quality of Stock Required

Stock going into bodies of the larger classes is of very high quality and practically free from defects. In open bodies a few small defects are allowed, the number and size depending on the location. In smaller and lighter bodies the requirements are not so severe; a mixture of woods is used, and some defects, such as small sound knots, are allowed; also, in soft maple, elm and gum considerable amounts of stain and dote are admitted. Recent studies have shown that many of the stains found in wood are caused by minute fungus organisms. Although stain itself may not impair the strength of a piece, it indicates that conditions are favorable for decay. If decay is present it may have advanced to a greater or less degree and possibly weakened the piece. Interior dote, commonly found in elm, soft maple and birch, is the result of fungus attack and greatly weakens pieces in which it is present. This defect is especially troublesome because its presence cannot be detected on the surface.

Although high-grade material is extensively utilized, to meet the exacting requirements of body parts, there is an opportunity for the use of sound low-grades for parts in which the factor of strength is not of great importance. A fair margin of safety is justifiable, but the use of clear stock where sound stock is sufficient introduces an unwarranted expense and at the same time wastes material that might serve higher purposes.

Investigations have not yet progressed to a stage where definite figures can be given as to what percentage of the total consumption for automobile bodies must be entirely clear, or how much partly defective stock may be used. From the standpoint of service, body parts containing a limited number of small sound defects will not be weak-

ened to a degree that will prohibit the use of this class of material.

Utilization of Lumber in Body Plants

One phase of plant operation in which body-builders are taking increasing interest is the degree to which lumber may be utilized. The amount of labor and time that can be devoted to the cutting up of lumber, of course, has a limit; beyond this point the cost of any further work on the particular lot of lumber is greater than the value of the material salvaged. Nevertheless, in many plants considerable care is used in cutting lumber to the best advantage. In the production of high-grade bodies it is sometimes the practice to sort out specially heavy and dense ash for use in certain main body parts, such as top-rails and pillars. In some plants narrow pieces are glued up to widths that can be used in various parts.

Figures on the waste of material, as estimated by body-builders, vary considerably, ranging from 20 to 50 per cent, with the average somewhere between 30 and 40 per cent. A few operators place their losses as low as 10 per cent, but the majority realize that usually more than one-third the lumber brought into the cutting room is lost in cutting-out defects, trimming ends and in getting out cuttings of specified sizes. The value or cost of the material lost at the saws amounts to an appreciable item when consumption over even a short period is considered. Although a certain amount of waste is unavoidable, careful work at the saws should reduce present figures.

In large-production plants making medium and low-priced bodies the operations are carried on very rapidly. Whereas the further advanced machining operations require a minimum of control, the operation of the saws requires considerable judgment on the part of the sawyer. He in reality determines what each board will produce. Obviously, when a sawyer is required to work at top speed to supply rough parts for the machine-room, he can hardly produce to the best advantage. If his task-rate is lowered so that he can reduce the lumber losses by only a few per cent, the value of the material saved will offset a considerable labor cost; furthermore, any saving of material thus effected will tend to reduce the amount of lumber necessary to complete a given number of jobs, reduce the demands on the dry-kilns and react favorably on transportation costs and storage space.

A considerable saving is made by gluing up stock to get the required sizes, thus avoiding the necessity for cutting some of the large curved parts from thick heavy lumber. Gluing makes possible the use of thinner and lower-priced stock, and it also reduces the losses that occur in band-sawing large cuttings.

One other important means by which a more complete utilization of raw materials can be brought about is the more general use of ready-cut small-dimension stock. This class of material is cut accurately to rough size at the mill and shipped to consuming plants ready for the final machining. It may be obtained air-dried or kiln-dried. Although frequent changes in models and designs of automobile bodies may cause changes in the sizes of parts and so render the use of ready-cut stock impracticable in some cases, it is nevertheless true that at present a number of automobile companies and body-builders are using considerable quantities of small-dimension stock with good success. Some are even buying parts machined and shaped ready for assembling. Large quantities of floor-boards and running-boards are now being bought in ready-cut form, as are also seat frames. Body builders have agreed that if the main parts such as sills,

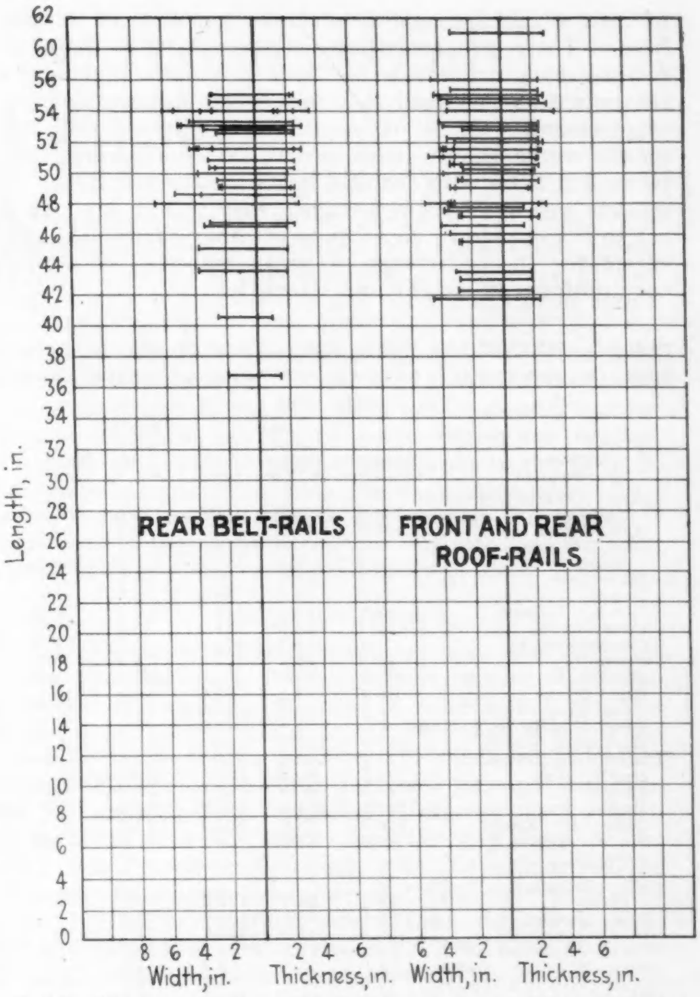

Fig. 3—Chart of the Variations in the Sizes of Rear Belt-Rails and Front and Rear Roof-Rails in Automobile Bodies

The Practically Uniform Width of the Roof-Rails in the Right Half of the Chart Should Be Noted, the Range Being from $2\frac{1}{2}$ to 4 In. with Only Few Exceptions. The Rear Belt-Rails in the Left Half Vary from 2 to 6 In. in Width, the Majority Falling between 2 and 4 In. The Thickness of the Great Majority of These Members Is between 2 and 3 In. The Same Method of Plotting Is Used in This Chart as in the Other Two That Are Reproduced in Figs. 1 and 2 Respectively

pillars and top-rails could be purchased ready-cut they would like to buy other body parts in the same way, but, as it is now, the smaller parts are cut from material left in cutting-out the larger ones. If, in designing new models, the rough sizes used in the preceding models could be adhered to in some measure, the use of ready-cut stock would be more applicable.

The advantages of this system are readily appreciated when consideration is given to the saving in freight and the quantity of raw material handled and to the elimination of part of the dry-kiln and cutting-room operations.

Suitability of Woods for Automobile Bodies

Automobile and body builders are very much interested in the possibility of finding woods that can be substituted for those now in use. The information collected in this survey showed that substitution has already taken place very extensively and that nearly all the hardwoods that occur in commercial quantities are being used. Those substituted have given satisfactory service with the exception of some of the softer and lighter woods that cannot be used safely in the heavier bodies.

A comparison of the properties of some of the woods used in automobile-body construction, with a discussion

of their advantages and disadvantages, will be of interest here. Their properties are compared with those of forest-grown white ash in Table 3. Ash is generally recognized as the wood that best meets automobile-body requirements. It is of moderate weight, is stiff and tough, works easily, holds screws well and warps and twists but little with changes in its moisture-content. It seasons well and is comparatively easy to kiln-dry. It is not so susceptible to decay as most other hardwoods and, except for the occurrence of brash material, is usually very uniform in weight and strength.

TABLE 3—STRENGTH OF WOODS USED IN AUTOMOBILE CONSTRUCTION IN PERCENTAGE OF THE STRENGTH OF FOREST-GROWN WHITE ASH

Species	Specific Gravity[4]	Strength as a Beam or Post	Stiffness	Shock-Resisting Ability	Hardness
Hardwoods					
Ash, White, Forest-Grown	100.0	100.0	100.0	100.0	100.0
Ash, Black	87.6	71.3	79.3	90.1	62.3
Ash, White, Second-Growth	111.3	122.5	117.6	119.6	118.9
Basswood	62.1	59.1	80.6	40.5	29.6
Beech	104.0	93.5	96.9	96.0	90.0
Birch, Yellow	105.2	104.8	116.8	120.6	80.9
Chestnut	75.7	66.0	71.9	53.4	49.2
Cottonwood	71.1	60.6	79.0	54.3	35.3
Cucumber	84.1	85.4	112.4	76.7	54.9
Elm, Rock or Cork	109.8	98.8	92.9	140.5	101.6
Elm, White	83.6	79.2	79.5	89.5	57.1
Gum, Red	84.7	80.7	91.5	75.5	59.0
Gum, Tupelo or Cotton	87.0	81.4	82.5	63.5	77.3
Hickories, Pecan	115.9	103.5	103.8	119.7	139.6
Hickories, True	123.7	126.6	120.2	173.9	150.4
Maple, Red	92.7	90.0	101.2	78.7	75.4
Maple, Silver	84.0	66.9	68.5	71.7	64.3
Maple, Sugar	107.1	104.7	105.9	90.5	103.0
Oaks, All Kinds	110.0	92.6	101.3	94.9	104.5
Poplar, Yellow	70.9	67.3	93.8	41.5	37.9
Conifers					
Fir, Douglas, Pacific Coast	86.8	95.7	122.1	59.9	58.3
Pine, Loblolly	96.4	93.7	105.6	71.0	60.0
Pine, Iongleaf	105.4	112.2	122.1	77.7	74.8
Pine, Shortleaf	94.5	94.1	100.6	69.7	64.0
Pine, Western White	75.1	75.5	99.7	53.8	37.0
Pine, Western Yellow	73.0	67.0	75.6	42.9	41.0
Spruce, Sitka	65.2	69.5	94.1	63.3	44.9

[4]Specific gravity, oven-dry, based on green volume.

Second-growth timber is popularly supposed to yield stronger and tougher material than that from virgin or forest-grown trees. The reason for this belief is that trees grown under the conditions that produced the original stands are of slower growth and have narrower annual rings than those of second growth. Under second-growth conditions, trees generally get full sunlight and are not crowded; as a result they grow rapidly, with wide annual rings and a large proportion of summerwood. In hardwoods, wide-ringed material is generally considered stronger and tougher than wood having narrow rings. Wide-ringed material usually has a greater proportion of summerwood and is therefore heavier per unit of volume. As a matter of fact, second-growth material, as it advances in age, has a naturally slower growth and may have annual rings no wider than virgin-growth trees of the same size. Also, the rate of growth of virgin-growth trees may be accelerated because of the removal of part of the stand, and as a result wide annual rings may be put on for a considerable period. For such reasons, nothing may be gained by specifying second-growth stock; as a rule it is best to rely upon the density of the material.

Hard maple is slightly heavier than white ash and is of equal stiffness and strength as a beam or post. It is not, however, so resistant to shock. Maple is uniform in strength and warps but little. It is somewhat difficult to kiln-dry without checking and is subject to decay. The opinion was expressed by a number of body-builders that maple does not hold screws so well as some of the other woods, and that, because of the smooth fine compact nature of the wood, paint and enamel may rub off, especially on exposed curved surfaces.

Soft maple is considerably lighter and softer, is weaker as a beam or post and is less shock-resistant than ash. It is readily subject to fungous attack, and care must be exercised not to use infected material where strength is essential. Soft maple is being used to a considerable extent in smaller bodies and has given good service.

Rock elm is used in some of the larger bodies, especially in open models. It is heavy, strong and tough, holds screws well and works well. White or gray elm is softer, lighter and generally weaker than rock elm; but it works more easily and, especially in lumber from mature trees, warps less. It is used in large quantities in the smaller and lighter bodies. Interior dote in elm is a common and serious defect. It has caused the degrading of large quantities of lumber and the loss of thousands of dollars annually.

Yellow birch is heavier, stronger, stiffer and more shock-resistant than ash but is not its equal in hardness. It is used to some extent in automobile bodies and, but for its high price, would doubtless be used more.

Red gum is considerably lighter, softer, weaker and less shock-resistant than ash. In open bodies of the light class, it is used in fairly large quantities for all parts, except lock pillars where it has not given satisfactory service. It is doubtful if it would stand-up in use in heavier bodies. Sap gum is merely the sapwood of the red gum tree and weight for weight has the same strength properties. It is more susceptible to stain and decay, however, than the heartwood.

No distinction is made between the different species of oak in automobile-body construction. The oaks are heavier than ash but do not equal it in shock-resisting ability and strength, when used as beams or posts. Oak is used in large quantities for floor-boards and seat frames and, to a limited extent, for sills. Builders object to it because of its tendency to develop surface checks in kiln-drying and because its open-porous texture prevents a smooth painted surface on exposed faces. But, aside from these points, its weight and high price, as compared with other ash substitutes, are drawbacks. Oak is used extensively for top-bows in open models, and wormy oak is used for running-boards.

Several other hardwoods, used to a limited extent at present, have properties that make them satisfactory for use in automobile-body work. Among them are beech, tupelo, cucumber, sycamore and hackberry. They are not available in as large quantities as are some of the other hardwoods, but the quantity is sufficient to allow for a considerable increase in their use.

Softwoods are coming into use in various parts of automobile bodies. Southern pine is used in floor-boards, seat frames, spring boards and running-boards. Other softwoods, such as pine, spruce and Douglas fir, should also be suitable for use in these parts. With possible changes in the methods of fastening and assembling, some of the woods mentioned which, although comparatively light and soft, are stiff and strong, should come into much more general use in automobile-body construction.

President Crane's Address at Annual Dinner

I ADMIT to you that I came here tonight with considerable trepidation. In the first place, our good old reliable toastmaster is missing. I got to know what to expect from him, the same old stuff, one of his well-known wheezes being the idea that a college degree may be a good sales argument but is of very little engineering value.

I had pretty well got over my tremors in this regard when I opened the morning paper last Sunday and began looking through it, and of course I knew we were to have a speech from a college president and I was a little worried by that. Ever since Mr. Edison started his questionnaire, I have been pretty nervous.

Well, along toward the back of the paper, I came across a full-sheet spread and in large letters on this spread, "Professor Jordan." Now, when I went to college, we used to have an examination supposedly lasting 3 hr. and they only asked us six questions. They gave me only 15 min. tonight and here were 66 questions and the chance that I might be asked all of them by the toastmaster was a good one. In college I only had one system; when the examination looked pretty dangerous, I searched for a few questions that I might know something about and tried to answer them. So I went through the 66 and down along about the middle, I came to a name "Crane-Simplex." "Well," I said, "here's something that I certainly ought to be able to answer." This related to a type of body finish, I found, said to be aristocratic. That interested me very much. We used to sell the Crane-Simplex with this type of finish and when we delivered the car, we would tell the owner that if he or his chauffeur would polish it diligently about ½ hr. a day, for the first month, it would then look almost as good as a varnish job.

To return to the more serious business of this meeting, I want to say that I am immensely proud to have been elected your President, because I am immensely proud of the Society. I think I can say that without being accused of self-congratulation. I have had little or nothing to do with bringing the Society up to its present position of importance in this great industry. From the days of Al Riker, the grand old man of Bridgeport, who was our first President, down through the list of Presidents, from all our Councilors for that period from 1905 to the present time, from our Committee-men on all the various managing committees and on the Standards Committee, the support of the forward movement of the Society has been whole-hearted, a most constructive support, a most enthusiastic support, and to that concerted effort we owe whatever we have at the present time.

Further than that, a most efficient, loyal and enthusiastic central-office organization has been built up under Coker Clarkson, without which the officers of the Society could not possibly function to the general advantage. That is why I say I have a right to say I am proud of the Society; because others have built it.

Standards

The activities of the Society, as probably most of you know, have been various. The Society was one of the first to take up seriously the matter of standardization and it has carried it on to the present time, spending a very considerable part of its income in this work. The standards have been supported to a considerable extent by the industry, by the presence of engineers of various companies interested in any particular line of standardization, and by contributions from the National Automobile Chamber of Commerce and other organizations. That has been satisfactory and well done, but the greatest support that the Society could get in standardization is more extensive use of standards. We do not feel that a standard is of value because it appears in the S. A. E. HANDBOOK; it means nothing whatever unless it is translated into the product that is delivered to the public. I hope that in the ensuing year we may see further steps along this line, largely in the matter of use.

Fuel Research

The Society has had another activity the last few years, and that is, a Research Department. That Department is naturally on trial. I believe that the first great undertaking of that Department has been of tremendous value to the industry. I think we may not know for the next 10 years just how valuable has been the fuel investigation, conducted jointly by our Research Department and Committee and the engineers of the American Petroleum Institute, with the support of the National Automobile Chamber of Commerce. It is difficult to point to a definite result from that work in so many dollars and cents. The great result has been the bringing together of the engineers of both industries in friendly conversations, in cooperative research, with the result that we are today building cars better suited to the fuel that we ought to get, and the oil companies are preparing for us a fuel much better suited to our requirements.

The Bureau of Standards

The work of this particular research was carried out by the engineers of the Bureau of Standards, and I cannot let tonight go by without taking the opportunity of asking for your support in the situation in which the Automotive Powerplant Section of the Bureau of Standards now finds itself. In the pressure for economy in Washington, which is amply justified, the Department of Commerce has suffered in its appropriations, and this particular section of the Bureau of Standards, which comes under the Department of Commerce, has been allowed so little in the budget as to be almost certainly wiped out. The matter has now gone beyond the Budget Committee, but it is still in the hands of the Senate and the House of Representatives to remedy this matter and to give the Bureau something more suited to its requirements in this work.

I will simply say that at the present time, in the budget, $15,000 has been allowed for the work of this division and that probably $100,000 would easily carry it and mean more than it has been used to getting in the past. It is a mere drop in the bucket, compared to what the division has done for the industry and what it stands ready to do for the industry in the future.

Ever since I have been connected with the activities of the Society in Council work, I have found that a continuous subject of discussion is, How can the Society

best serve its members? It is a very difficult proposition. The Society exacts from the membership certain annual dues. In addition, due to the efficient management of THE JOURNAL, it has an income from that source considerably greater than the amount of the dues. What we are trying to do is to spend that income in a business-like way, in a way that will confer the greatest benefit on the members of the Society and on the industry as a whole.

THE SECTIONS

The Country is so large that we have a most difficult problem to meet all requirements in this regard. We have established Sections in the various centers where automobile engineers are gathered, to attempt to bring the activities of the Society closer to the members, knowing well that the members cannot always get to the national meetings of the Society. The best method of handling the Sections and their relations with the parent Society are the most important problems to be considered this year, and with the help of a very efficient committee headed by Past-President Bachman, I believe we will reach a solution that will be satisfactory to all the members. However, when that is accomplished, it is only accomplishing part of the machinery. We know today that there are men in the industry who ought to be members of the Society and are not members. We know that many members of the Society are not as active as we would like them to be in the Society's councils, in its meetings and in the standards work. I wish that I could bring home to the Executives in this industry the fact that it is part of the work of every one of their engineers to participate in the Society's activities.

VALUE OF THE SOCIETY

President Burton spoke to you about the mind. I think the universal experience of all the men who have been particularly active at Society meetings is that attending such meetings is the most stimulating thing to the mind along the lines of our work, that they can do.

Furthermore, no organization in the industry today is so big that it can do without the Society. I have talked to many men who have been active in Society affairs and they are unanimous in saying that they have invariably got infinitely more from the Society than they were ever able to give to the Society.

In furthering the idea of getting the Society closer to the members, we have changed this year the order of our meetings and will hold the Annual Meeting at Detroit. That should give an opportunity to many to attend the technical sessions who have been prevented from doing so in the past. I sincerely hope that I will meet all of you and many more of the members there.

HIGHWAY ECONOMICS AND FINANCE

THE reemergence of the highway as a factor in the transportation of people and goods has brought forth problems to be solved if the use and the development of the highways is to be along the most economic lines. Observations have been made in Connecticut to determine the character and the amount of the commodities hauled by highway, the method of hauling and the length of the haul for the commodities moving over the roads of the State.

It is estimated that 1,019,688 net tons of commodities was transported over the Connecticut highway system in the 3-months' period beginning September, 1922. A large part of this movement was distinctly a service that could be rendered only by improved highways as more than a third of the tonnage moved only from 1 to 9 miles and nearly another third from 10 to 29 miles.

In recent years much discussion has been had as to methods of highway financing. In some quarters a feeling has been expressed that the distribution of the cost to property owners and motor-vehicle operators has not been equitably adjusted. To ascertain the facts, the United States Bureau of Public Roads has undertaken to make a thorough study of the sources of highway revenue. Attention has first been given to county and local road funds, four counties in Wisconsin being selected for study.

Among the significant findings, some of which are at variance with the opinions that are widely held at present are the following:

(1) The major portion of the total highway funds are raised by township and county units rather than by the State
(2) Real property taxation produces 62 per cent of the highway revenue derived from these counties
(3) Vehicle license-fees produce 9 per cent of the total funds raised in the counties
(4) Significant reduction of real property taxation can be made only by a reduction of county and local taxes.

—T. H. McDonald.

ON SUCCESSION IN POSITION

SOME day, at some future time, someone is sure to take your place. It may be your partner, it may be your son, it may be your assistant, or it may be some fellow you will never know, but someone will take your place when it's time for you to go.

What are the characteristics of this someone, this man to come when you are gone; the man who is to take the place you now hold, to improve it or degrade it? You are partly responsible for him and his success or failure.

To the small-thinking man, this inevitable man to come is an intruder, a nightmare. To the big man, he is an inspiration. The big man would like to take the hand of the coming man and lead him around some of the pitfalls he has encountered and give him the benefit of knowledge and wisdom gained only through hard work and experience. He would like to give him the gospel of cheer and show him the best road to travel; to give him the history of his business, of his mistakes, of battles won and lost.

The man to go would like to help the man to come to take up his work and improve on it. Such is the attitude of the big-thinking man toward the man who some day will take his place.—*Industrial Management.*

Notes on a Sand-Cast Aluminum-Copper-Nickel-Magnesium Alloy

By LIEUT. A. J. LYON,[1] U. S. A., AND SAMUEL DANIELS[2]

ANNUAL MEETING PAPER — *Illustrated with* PHOTOGRAPHS AND CHARTS

THE importance of the development of a light alloy for use in parts that are subjected to elevated temperatures has already been emphasized in many papers, among which that by S. D. Heron on Air-Cooled Cylinder Design and Development[3], should be particularly mentioned. It was with this purpose in view that the foundry of the Engineering Division of the Air Service at McCook Field undertook a brief survey of the alloying, the casting, the heat-treatment, the physical properties and the metallography of an aluminum-copper-nickel-magnesium alloy of the Magnalite type as sand cast under ordinary foundry conditions.

It was found that the alloying involved no particular difficulty. The casting, however, showed the necessity for proper pouring temperatures, gating and placing of the chills and the risers. Several photographs are shown illustrating satisfactory and unsatisfactory methods of molding pistons and air-cooled cylinder-heads.

The heat-treatment of these alloys must be carefully conducted, since not only is the alloy tender at the quenching temperature, but it is also very susceptible to small variations in quenching temperature. With proper attention to manipulation, consistent results can be always obtained; and rejections from warpage and distortion are negligible. The treatment best combining the factors of physical properties and economy is to heat the alloy at 975 deg. fahr. for 5 hr. and then to quench in boiling water or air according to the design of the casting. The alloy is subsequently aged at 212 deg. fahr. for 16 hr., an overnight treatment.

The physical properties of this alloy at ordinary temperatures as cast are very much improved by suitable heat-treatment; and at 600 deg. fahr. the alloy shows the remarkable properties of being slightly stronger than it is at room temperature either as cast or heat treated. The extended heat-treatments partaking of the nature of the malleablizing process in cast iron produce even better results than the short treatment described above, but the former is probably not economically justifiable, although it produces ultimate tensile-strengths as high as 45,000 lb. per sq. in. and Brinell hardness values as high as 105.

Alloy Condition	Aluminum-Copper-Nickel-Magnesium As Cast	Aluminum-Copper-Nickel-Magnesium Heat Treated	8 Per Cent Copper, 92 Per Cent Aluminum As Cast	10 Per Cent Copper, 90 Per Cent Aluminum As Cast
Ultimate Tensile-Strength, lb. per sq. in.	25,020	37,220	20,670	20,600
Brinell Hardness	74	93	52	58
Elongation in 2 In., per cent	0.7	1.1	2.0	1.2
Specific Gravity	.....	2.73	2.83	2.84

The average properties of the sand-cast and heat-treated alloy compared with some of the better known light casting-alloys are as tabulated at the bottom of the preceding column.

The metallography of the alloy is quite complex. A number of photomicrographs are included which not only show the constituents, but the changes in structure resulting from heat treatment.

THE aluminum-base alloys with copper, nickel and magnesium additions have been in use in the United States under the trade name of Magnalite since 1913. Few results on the chemical composition and the mechanical tests of alloys of this type when sand cast by the ordinary methods used in the non-ferrous foundry have been published. The National Physical Laboratory of England, under the direction of Dr. Walter Rosenhain, has performed considerable fundamental research on these alloys when used in chill castings and in the wrought condition. The results of this work have been published in the 11th Report to the Alloys Research Committee of the Institution of Mechanical Engineers and in a paper presented before the Institute of Metals entitled the Production and Heat-Treatment of Chill Castings in an Aluminum Alloy (*Y*),[4] and in many cases were confirmed by the findings of the present paper. They show that the Magnalite alloy, designated as *Y* alloy, has the remarkable property of substantially retaining its strength at elevated temperatures up to about 500 deg. fahr.

The purpose of the present paper is to describe the foundry practice and to tabulate the physical properties of the sand-cast aluminum-base alloy containing 4 per cent of copper, 2 per cent of nickel and 1.5 per cent of magnesium; and also to outline the methods of heat-treating this alloy to obtain the maximum hardness and tensile properties. The physical testing results contained in this paper were obtained in connection with the manufacture of pistons and air-cooled cylinder-heads for aircraft engines cast by the foundry of the Engineering Division of the Air Service at McCook Field. The metallographic structures produced by the various heat-treatments will be illustrated and compared to that of the alloy as cast.

METHOD OF ALLOYING

The composition of the raw materials and of the alloys made for this investigation and in connection with the regular routine foundry work are shown in Tables 1 and 2. The copper and the nickel were introduced into the melt in the form of a hardener containing approximately 40 per cent of copper, 20 per cent of nickel and 40 per cent of aluminum. The procedure in making the hardener was to charge together 20 parts of copper, 40 parts of a cupro-nickel containing 50 per cent of copper and 50 per cent of nickel, furnished by the Metals Thermit Corporation, New York City, and 20 parts of

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[3] See THE JOURNAL, April, 1922, p. 244.

[4] See the *Journal of the Institute of Metals*, vol. 29, p. 191.

TABLE 1—COMPOSITION AND DISPOSITION OF RAW MATERIALS

Metal	Melt No.	Copper	Nickel	Magnesium	Iron	Silicon	Manganese	Aluminum[5]	Used in Melt No.
Aluminum Ingot	1660	<0.01			0.44	0.12	<0.01	99.43	3012
	1799	0.02			0.38	0.36	Trace	99.24	1849, 1853, 1865 and 2222
	2063	0.02			0.28	0.14		99.56	2437 and 2604
Aluminum-Copper-Nickel	1848	37.08	17.92		0.95	0.12			1849, 1853 and 1865
Hardener	2203	40.00	20.00					20.00	2222, 2437, 2604 and 3012
Magnesium, Stick	919			99+					1849, 1853 and 1865
Slab	2013			99+					2222, 2437, 2604 and 3012

[5] By difference.

aluminum into a plumbago crucible. The charge was then melted in an oil-fired furnace, in which the temperature should not exceed 1800 deg. fahr. The remainder of the aluminum ingot, 20 parts, was next alloyed. Finally, the metal was poured into iron molds.

In founding the aluminum-copper-nickel-magnesium alloy itself, the necessary amounts of aluminum ingot

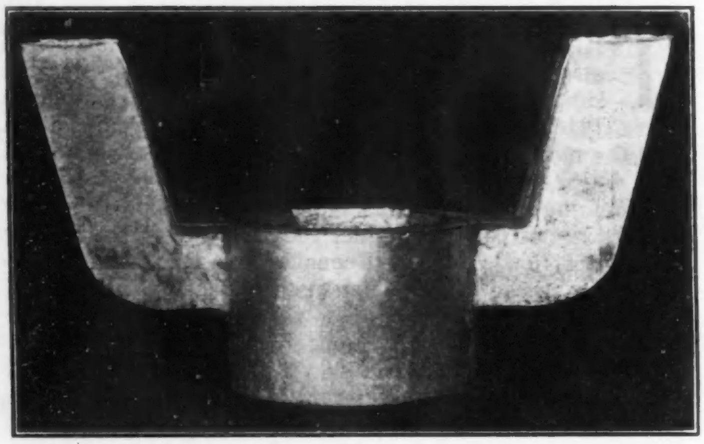

FIG. 1—RADIAL-ENGINE PISTON CASTING THAT WAS POURED DIRECTLY INTO THE RISER

This Method of Producing a Casting Was Not Satisfactory Because the Rate of Pouring Could Not Be Controlled, the Rapidity of Feed Causing a Coarse Structure and Pin-Holes

and of the hardener were melted together in a plumbago crucible. The magnesium metal slab or stick was introduced just before pouring and in solid form, plunged beneath the surface of the molten metal and held there until completely liquid. The alloy was then well stirred and cast into iron molds. It has been found that more consistent results are obtained when castings are poured from the remelted pig than when they issue directly from the original melt.

METHODS OF CASTING AND TESTING

The Magnalite alloys are slightly more difficult to cast than the more or less conventional straight aluminum-copper alloys on account of the fact that they are prone to pin-holes. The fractures both of heavy sections as cast and of heat-treated material are often stained or discolored and porous, probably because of oxidizing reactions.[6] In the casting proper it has been found that the rate of pouring, the method of gating and the placing of the risers involve more consideration in the case of the aluminum-copper-nickel-magnesium alloy than is necessary for the less complex aluminum-copper alloys. In general, the gates should be choked and the metal poured very slowly from a temperature usually between 1250 and 1310 deg. fahr., depending upon the type and the design of the casting. Chills prevent pin-holes and insure sound metal; they are always used at heavy sections.

Figs. 1 to 3, inclusive, illustrate methods of gating and emplacement of risers in an air-cooled engine piston of the ribbed type. The molding procedure shown in Fig. 1 was unsuccessful because the rate of pouring could not be controlled, the rapidity causing coarse structure and pin-holes. When, however, the metal was introduced through the small horseshoe gate depicted in Fig. 2, the results were satisfactory. The change in the method of gating shown in Fig. 3, while desirable from the standpoint of soundness, proved less practicable because of slight shrinks at the junction between the gate and the casting proper. A horn gate to the center of the crown of the piston was unsuccessful for this same reason. In general, it has been found necessary to keep the gates away from the crown and the land surfaces, as

[6] See the *Journal of the Institute of Metals*, vol. 29, p. 192.

TABLE 2—COMPOSITION AND PHYSICAL PROPERTIES OF THE ALUMINUM-COPPER-NICKEL-MANGANESE ALLOY AS CAST

Melt No.	Ultimate Tensile-Strength, Lb. Per Sq. In.	Elongation in 2 In., Per Cent	Brinell Hardness	Pouring Temperature, Deg. Fahr.	Composition
1849	25,230	0.8	70	1300	New melt. Mixed to Cu 4.0, Ni 2.0 and Mg 1.5
1850	24,830	0.8	..	1300	Ingot from Melt No. 1849
1853	23,500	0.5	80	1300	New melt. Cu 3.68, Ni 1.86, Mg 1.46, Fe 0.81 and Si 0.40
1856	25,360	0.5	80	1400	Ingot and gates from Melt No. 1853
1860	23,100	0.5	80	1410	Gates from Melt No. 1853
1865	24,010	0.5	72	1400	New melt. Mixed to Cu 4.0, Ni 2.0 and Mg 1.5
2048	25,060	0.8	..	1295	Gates from Melt No. 1865. Cu 4.25, Ni 1.49, Mg 1.24, Fe 0.65 and Si 0.36
2222	26,060	1.5	..	1300	New melt. Cu 4.12, Ni 2.11, Mg 1.62, Fe 0.59 and Si 0.36
2437	24,450[a]	1.0[a]	69[a]	1300	New melt. Cu 4.01, Ni 1.94, Mg 1.52, Fe 0.38 and Si 0.28
2582	27,430	0.5	..	1300	Gates from Melt No. 2222. Cu 4.03 and Mg 1.52
2604	23,530	0.5	..	1300	New melt. Cu 4.20, Ni 2.05, Mg 1.55, Fe 0.29 and Si 0.17
2699	28,430	0.5	..	1300	Ingot from Melt No. 2604
3012	......	...	..	1300	New melt. Cu 3.76, Ni 1.85, Mg 1.68, Fe 0.35 and Si 0.20
Average	25,030	0.7	74		

[a] Average of six test-specimens.

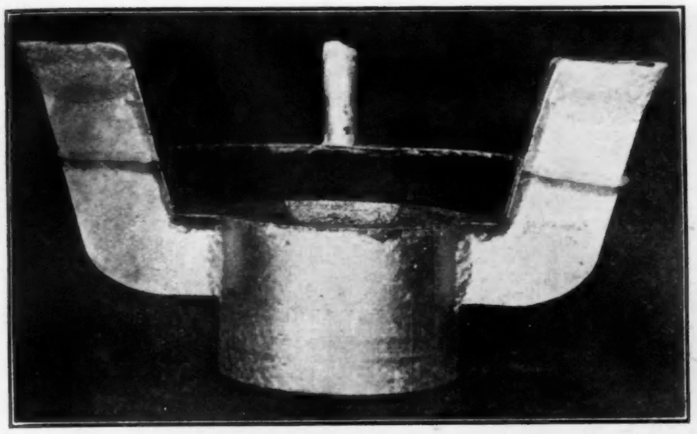

FIG. 2—CASTING OF AN AIR-COOLED ENGINE PISTON OF THE RIBBED TYPE THAT WAS POURED THROUGH A HORSESHOE INTO THE RISER

The Results Secured by This Method of Gating Were Satisfactory

the resulting minute shrinks cause trouble in service when gases start to erode the piston. With pistons of heavy crown section, aluminum or carbon block chills in segments should be used. If single-piece chills are used the castings will blow. It is considered good practice to dip these chills, especially the carbon block, in kerosene.

The air-cooled cylinder-heads shown in Figs. 4 and 5 are poured at 1350 deg. fahr. and in dry sand molds on account of the thin fins, which vary in thickness from ⅛ in. at the root to 1/16 in. at the tip. Little trouble

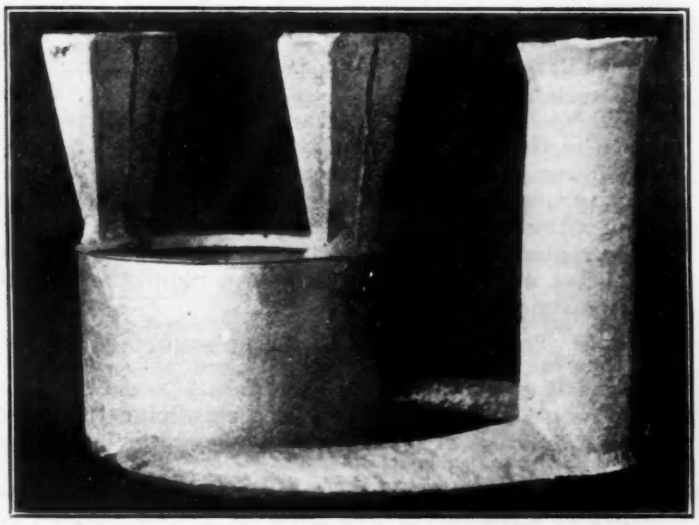

FIG. 3—AIR-COOLED ENGINE-PISTON CASTING IN WHICH THE HORSESHOE GATE LED INTO THE LAND SECTION

While This Method of Gating Proved To Be Desirable from the Standpoint of Soundness, Slight Shrinks at the Junction between the Gate and the Casting Proper Demonstrated That It Was Not Practicable

was encountered from pin-holes in the heavy sections, as will be seen from an examination of Fig. 5.

Both pistons and air-cooled cylinder-heads are successfully heat-treated after casting if carefully handled. The treatment at McCook Field for pistons is to heat at 975 deg. fahr. for 5 hr. and quench into and age in boiling water for 16 hr.; and that for the air-cooled cylinder-heads is to heat-treat in wire baskets at 975 deg. fahr. for 5 hr. and air cool, and then to age in boiling water for 16 hr.

In Fig. 6 and Table 3 are shown how Brinell-hardness tests are made on representative heat-treated pistons and what results are obtained. They are particularly interesting because, with the exception of two values of 74 and 80, every result in the table is greater than 82; and further, because a maximum of 105 was obtained in a heavy section. Careful measurements for distortion and warpage were made on representative heat-treated pistons and on the cylinder-heads, as it was thought that this alloy would be susceptible to changes in dimensions

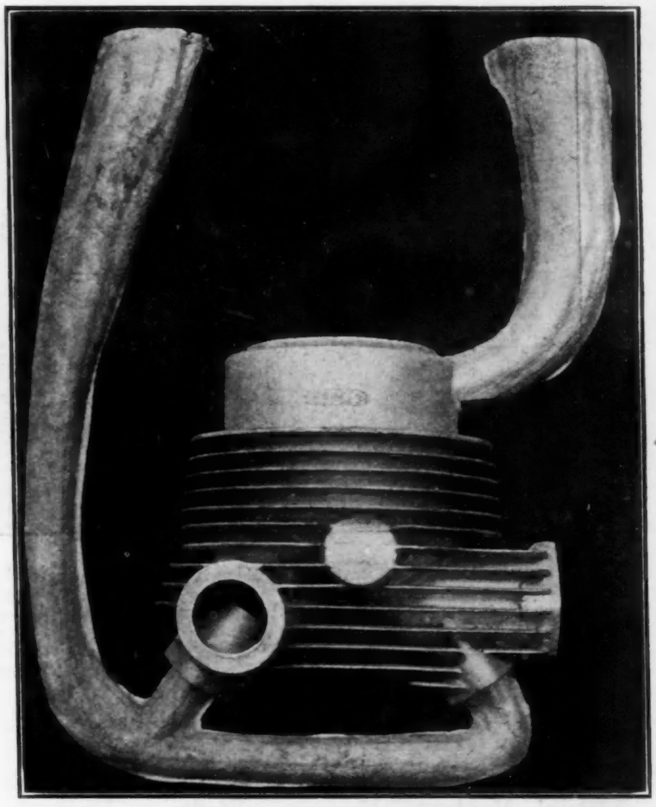

FIG. 4—AN AIR-COOLED-ENGINE CYLINDER-HEAD CASTING

This Casting Was Poured from a Temperature of 1350 Deg. Fahr. into a Dry-Sand Mold

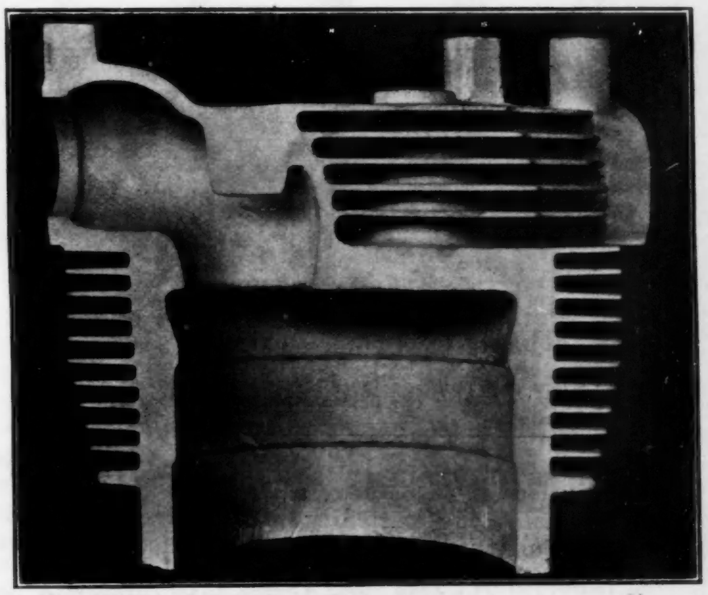

FIG. 5—CROSS-SECTION OF A CYLINDER-HEAD CASTING FOR AN AIR-COOLED ENGINE

It Should Be Noted That the Fins, Which Vary in Thickness from ⅛ In. at the Root to 1/16 In. at the Tip, Are Clean and Sharp and That No Trouble from Pin-Holes Was Experienced in the Heavy Sections. This Casting Was Made in a Dry-Sand Mold at a Pouring Temperature of 1350 Deg. Fahr.

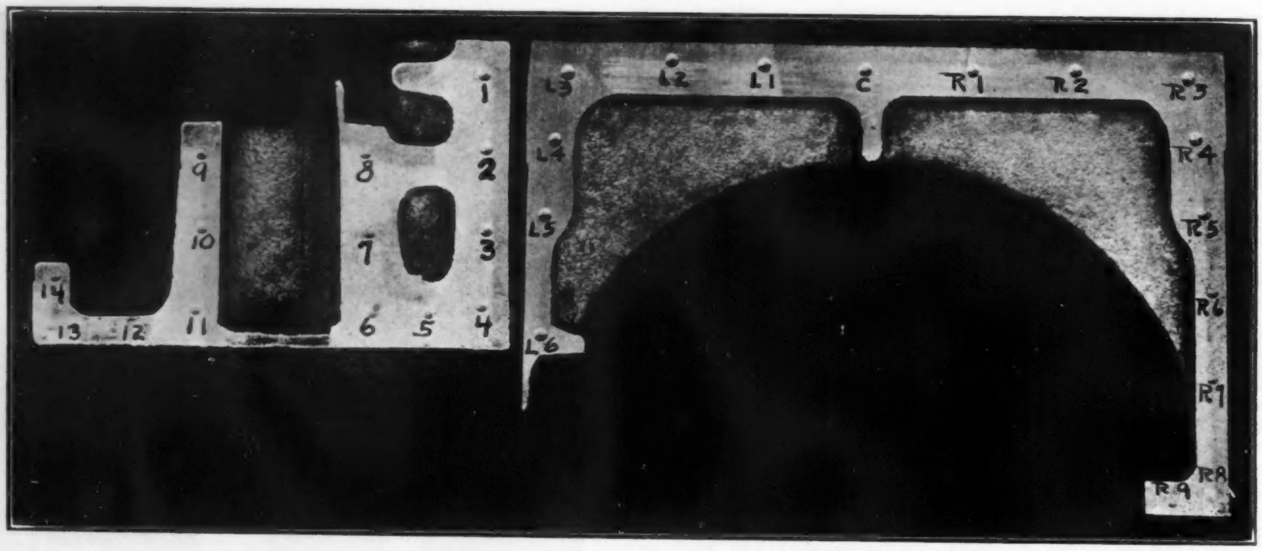

FIG. 6—CROSS-SECTION OF RADIAL-ENGINE PISTON SHOWING THE LOCATION OF THE POINTS TESTED FOR HARDNESS
The Results of the Hardness Tests Are Presented in Table 4 and the Numbers on the Photograph Correspond to the Points Given in the First Column of the Table. The Brinell Values Obtained Are Interesting Because, with the Exception of Points 1 and 2 of One Piston That Had Hardness Values of 74 and 80 Respectively, the Hardness in Each Case Is Greater than 82 and a Maximum of 105 Was Obtained in the Heavy Sections of the Other Piston at Points R5, R6, R7, R8, 13 and 14

TABLE 3—BRINELL AND ROCKWELL HARDNESS OF SECTIONS THROUGH RADIAL ENGINE PISTON

	Piston 3011-11 Head and Skirt		Piston 3005-6 Head and Skirt	
Station[7]	Brinell Hardness	Rockwell Hardness	Brinell Hardness	Rockwell Hardness
C	86	92	83	89
L 1	93	95	86	87
L 2	96	94	86	87
L 3	100	97	83	90
L 4	100	96	89	93
L 5	100	98	89	94
L 6	105	99	93	94
R 1	100	98	83	90
R 2	100	95	86	90
R 3	96	95	86	89
R 4	100	98	86	90
R 5	105	98	86	91
R 6	105	99	86	88
R 7	105	98	93	90
R 8	105	100	86	90
R 9	100	102	89	93
	Boss		Boss	
1	89	92	74	85
2	93	94	80	89
3	86	92	83	90
4	93	95	83	89
5	93	94	83	89
6	93	96	83	89
7	93	96	83	89
8	93	94	86	91
9	100	..	93	..
10	100	95	89	93
11	96	97	93	93
12	..	96	89	92
13	105	100	93	92
14	105	101	93	..

[7] Letters and numbers in this column correspond to those in Fig. 6 and show the points at which the various values were obtained.

due to the quenching operation. No measurable changes in dimensions could be detected.

Incidentally, the machining properties of the heat-treated aluminum-copper-nickel-magnesium alloy have been reported by several shops as very satisfactory.

The average ultimate tensile-strength, percentage of elongation and Brinell hardness of the several melts as cast are indicated in Table 2. Each annotated result is, unless otherwise stated, the average of three standard tensile specimens, cast to 0.505 in. in diameter in green-sand molds, with a common riser of 1.0 in. in diameter and 2.5 in. in height at one end, and a pouring sprue of the same dimensions at the other. As cast or as heat-treated the test-specimens were pulled between wedge grips in a 20,000-lb. Olsen machine, and the results of these tests are presented in Tables 4 to 7, inclusive. After rupture the percentage of elongation was determined by fitting the broken bars together as closely as possible and measuring the extension to the nearest 0.01 in. The Brinell-hardness values for a 500-kg. (1102.311-lb.) load and a 10-mm. (0.3937-in.) ball were taken on broken specimens. The specific gravity determinations were made by the ordinary displacement method. The tests at 600 deg. fahr. were conducted with the test-specimens in a tubular Hoskins electric furnace. All tests were made within 48 hr. after casting or heat-treatment, with the exception of those indicated in Table 7, which were conducted about 2 months after the completion of the heat-treatment.

METHODS OF HEAT-TREATING

A fairly comprehensive series of heat-treatments was investigated with a view toward ascertaining the effect of short soakings at 975 deg. fahr. followed by quenching into and aging in boiling water, paralleling the treatment of sheet duralumin except in the matter of the quenching temperature; the effect of a 5-hr. soaking at 975 deg. fahr. followed by quenching into boiling water or in air and then aging for 16 hr. at various temperatures; the effect of a 96-hr. soaking under approximately equilibrium conditions at various temperatures from 875 to 1025 deg. fahr., followed by quenching in cold water and aging at 300 deg. fahr. for 8 hr.; and the effect of a boiling water quench upon the properties of the alloy at 600 deg. fahr.

All of the castings to be heat-treated were first suitably wrapped with a soft iron wire to facilitate handling, for the alloy is tender at elevated temperature. The heating medium was uniformly an electric furnace that could be automatically controlled for close work at any temperature to within plus or minus 10 deg. fahr. over the central part of the furnace. In the experiments designed to determine the effect of the aging temperature, the heating at 300 and at 750 deg. fahr. was accomplished in an automatically controlled electric furnace,

while that at 500 deg. fahr. was carried out in tempering oil.

Physical Properties

The physical properties of the alloy as sand cast are given in Table 2. For 12 melts the average ultimate tensile-strength was 25,020 lb. per sq. in. and the elongation 0.7 per cent in 2 in. The Brinell hardness for six melts averaged 74.

TABLE 4—PHYSICAL PROPERTIES OF HEAT-TREATED SPECIMENS OF THE ALLOY[8] AFTER BEING GIVEN FROM 1 TO 5-HR. SOAKING AT 975 DEG. FAHR. AND QUENCHED INTO AND AGED IN BOILING WATER FOR 2 HR.

Time at 975 Deg.Fahr., hr.	1	3	5
Ultimate Tensile-Strength, lb. per sq. in.	29,250	33,100	33,350
Elongation in 2 In., per cent	0.5	1.0	1.0
Brinell Hardness	89	90	83
Specific Gravity	2.729	2.734	2.725

[8] Melt No. 2549, remelted from Melt No. 2437, the composition of which is given in Table 2.

Table 4 shows that shorter periods of soaking at 975 deg. fahr. than from 3 to 5 hr. do not develop, for quenching into and aging for 2 hr. in boiling water, the optimum properties of the alloy. The 5-hr. soaking was selected as the most advisable and economical treatment, because the resulting physical properties, although inferior to the 96-hr. treatment to be described later, were better in proportion to the time spent in securing them, and further, it was considered the minimum period of soaking that would allow the alloy to attain the approximate limit of physical growth. This last consideration is very important, for in pistons the alloy is at temperatures of from 400 to 500 deg. fahr. for long periods of time. It was found that pistons of this alloy, running for 100 hr. on dynamometer test, suffered a growth of as much as 0.004 in. when their heat-treatment involved only a 2-hr. soaking at the quenching temperature, but that when the 5-hr. heating was employed no appreciable alteration in dimensions occurred. This physical growth is a factor apart from the apparently negligible dimensional change that arises from the quenching and aging operations where the contraction and the expansion may balance one another.

TABLE 5—COMPOSITION AND PHYSICAL PROPERTIES OF HEAT-TREATED SPECIMENS OF THE ALLOY THAT WAS GIVEN 5-HR. SOAKING AT 975 DEG. FAHR. AND WAS QUENCHED INTO AND AGED IN BOILING WATER FOR 16 HR.

Melt No.	Ultimate Tensile-Strength, Lb. per Sq. In.	Elongation in 2 In., Per Cent	Brinell Hardness	Composition[9]
2999	41,330	1.0	89	Remelt from Melt No. 2582
3002	42,010	1.0	96	Remelt from Melt No. 2604
3005	35,350	1.0	93	Remelt from Melt No. 2604
3012	34,930	1.0	86	New Melt[10]
3015	40,360	1.0	96	Remelt from Melt No. 3012
3018	35,080	1.2	93	Remelt from Melt No. 3012
3027	36,950	1.5	86	Remelt from Melt No. 3012
3036	36,130	1.3	100	Remelt from Melt No. 3012
3038	38,850	1.5	100	Remelt from Melt No. 3012
3040	33,860	1.0	93	Remelt from Melt No. 3012
3041	35,150	1.0	93	Remelt from Melt No. 3012
Average	37,270	1.1	93	

[9] See Table 2 for composition of original melts.
[10] Cu 3.76, Ni 1.85, Mg 1.68, Fe 0.35 and Si 0.20.

Inasmuch as the quenching operation would set-up stresses in the material, it was thought expedient to increase the time at aging temperature from 2 to 16 hr. at 212 deg. fahr., an overnight process, and simultaneously to determine the effect of temperature of aging.

In Table 5 are given the results of test on 11 melts, specimens from which were heated at 975 deg. fahr. for 5 hr. and then quenched into and aged in boiling water for 16 hr. The range of ultimate tensile-strength is from about 34,000 to 42,000 lb. per sq. in. and the average 37,270 lb. per sq. in.; the percentage of elongation varies between 1.0 and 1.5, the average being 1.1; and the Brinell hardness lies between 86 and 100, 93 being the average. Each one of the results for ultimate tensile-strength contained in this table is, as has been previously stated, the average for three test-specimens treated together. In the heat-treated bars throughout this investigation, very seldom did the ultimate strength of the bars in the group of three differ from one another by more than 3000 lb. per sq. in. The ultimate tensile-strength of the bars as sand cast tended to be more erratic. The beneficial effect from heat-treatment was most consistently evident in the uniformity of results. The remelted material possessed the peculiarity of having somewhat better tensile properties and in general considerably greater hardness, as reported in Tables 4 and 5, than the original melt as given in Table 5. The effect of the 16-hr. aging in boiling water was to produce slightly greater ultimate tensile-strength and hardness than the 2-hr. aging in boiling water following the 5-hr. treatment at 975 deg. fahr.

TABLE 6—PHYSICAL PROPERTIES OF HEAT-TREATED SPECIMENS OF THE ALLOY[11] THAT WAS GIVEN A 5-HR. SOAKING AT 975 DEG. FAHR. AND WAS QUENCHED AND AGED FOR 16 HR. AT VARIOUS TEMPERATURES

Aging Temperature, deg.fahr.	65	212	300	500	750[b]
Ultimate Tensile-Strength, lb. per sq. in.					
Quenched in Boiling Water	33,980	38,970	39,640	34,340	24,600
Quenched in Air	....	34,550	35,140	30,790	....
Elongation in 2 In., per cent					
Quenched in Boiling Water	1.0	0.8	1.0	1.0	2.0
Quenched in Air	....	1.0	1.0	1.0	....
Brinell Hardness					
Quenched in Boiling Water	90	93	92	88	60
Quenched in Air	....	87	87	76	....

[11] Remelted from Melts Nos. 2437, 2582 and 2604, the compositions of which are given in Table 2.
[b] Aged for only ½ hr. at 750 deg. fahr.

It will also be noted in Table 5 that several results from the same ingot, Melt 3012, apparently did not respond uniformly to heat-treatment, a variation among the remelts of 6000 lb. per sq. in. in ultimate tensile-strength being shown. The fact is, however, that remelts do act alike when the temperature from which they are quenched is closely controlled. It happened in the case of the results mentioned above that the test-specimens were placed both in front and in back of batches of pistons in an electric furnace 30 in. deep, in which a considerable temperature gradient existed, so that the bars were probably quenched from 975 deg.

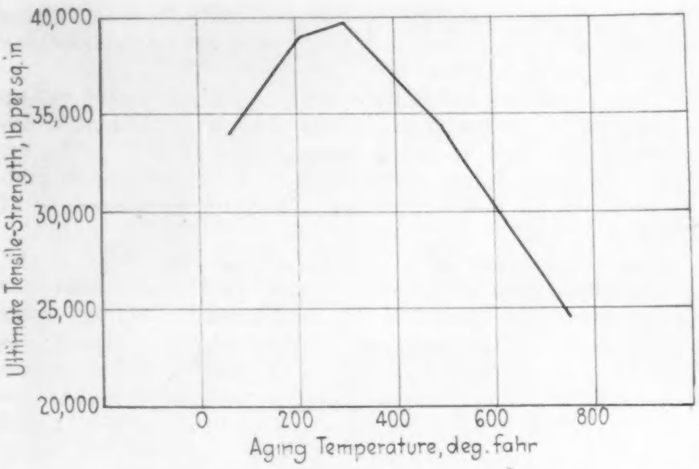

FIG. 7—EFFECT OF AGING TEMPERATURE ON THE PHYSICAL PROPERTIES OF THE ALLOY

These Specimens Were Heated at 975 Deg. Fahr. for 5 Hr., Quenched in Boiling Water or in Air and Aged at the Temperatures Given in Table 6 for 16 Hr. As a Result of These Experiments It Was Found That after Heating and Quenching Either in Boiling Water or Air, Reheating to or Aging at Temperatures of from 212 to 300 Deg. Fahr. Produced the Best Combination of Ultimate Tensile-Strength and Brinell Hardness for the Usual Elongation of 1 Per Cent, the Values Being Approximately 39,000 Lb. per Sq. In. and 92 Respectively

fahr., plus or minus 25 deg. fahr. These results, as are those included in Table 6, therefore are the product of conditions that would exist in ordinary practice and are accordingly useful.

The experiments designed to investigate the effect of aging temperature as reported in Table 6 and Fig. 7 disclosed the fact that, after the 5-hr. treatment at 975 deg. fahr. and quenching either in boiling water or in air, reheating to, or aging at, temperatures of from 212 to 300 deg. fahr. produces the best combination of ultimate tensile-strength, about 39,000 lb. per sq. in., and of Brinell hardness, about 92, for the usual elongation of about 1 per cent. Aging at room temperature is not so efficient as the higher temperatures mentioned above and at which acceleration of the attainment of the end properties occur. At some temperature beyond 300 and below 500 deg. fahr. a sharp break in the ultimate tensile-strength and in the elongation takes place and aging at 750 deg. fahr. causes a reversion in the alloy very nearly to its physical characteristics as cast.

In Table 7 are given the results from the 96-hr. heating at various temperatures which were controlled to plus or minus 10 deg. fahr. followed by quenching in cold water and aging at 300 deg. fahr. for 8 hr. Fig. 8 indicates clearly the gradual improvement of the physical properties with an increase of the quenching temperature up to 975 deg. fahr., where the best properties are obtained. That close control of the quenching temperature of the aluminum-copper-nickel-magnesium alloy is necessary becomes very evident when it is considered that the optimum properties for 975 deg. fahr. of an ultimate tensile-strength of 44,480 lb. per sq. in., an elongation of 1.8 per cent, and a Brinell hardness of 103 are lost to a very considerable degree with quenching temperatures of 950 and 1010 deg. fahr., the drop in the neighborhood of the latter temperature being possibly due to the melting of the compound $CuAl_2$. It will also be noted that the specific gravity falls from about 2.72 to 2.66. The effect of a lapse of time after quenching and before aging at 300 deg. fahr. is not altogether clear from these experiments, but in general it would appear

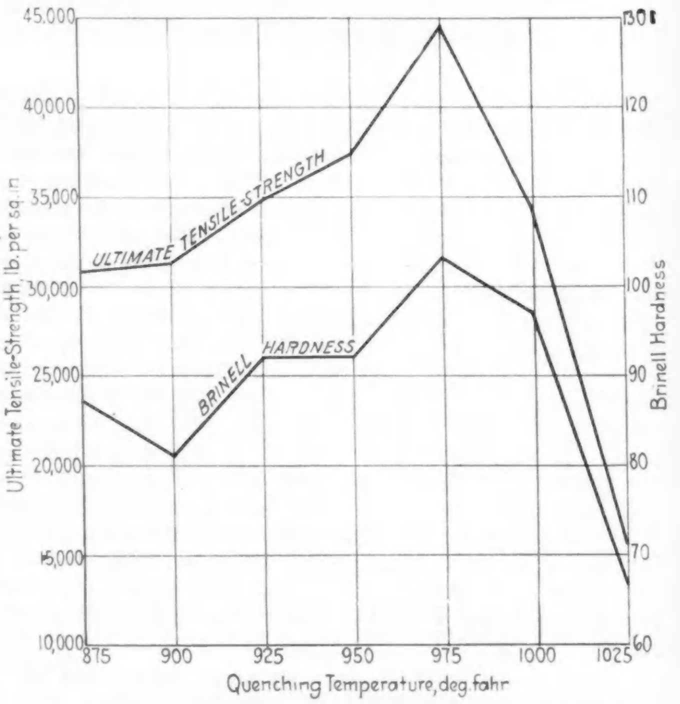

FIG. 8—EFFECT OF THE QUENCHING TEMPERATURE ON THE PHYSICAL PROPERTIES OF THE ALLOY

The Specimens Were Heated at the Temperatures Given in Table 7 for 96 Hr., Quenched in Cold Water and Reheated to, or Aged at, a Temperature of 300 Deg. Fahr. for 8 Hr. A Gradual Improvement in the Physical Properties with an Increase in the Quenching Temperature Was Noted up to 975 Deg. Fahr. Where the Best Results Were Obtained

TABLE 7—PHYSICAL PROPERTIES OF HEAT-TREATED SPECIMENS OF THE ALLOY[12] AFTER BEING GIVEN A 96-HR. SOAKING AT VARIOUS TEMPERATURES, QUENCHED IN COLD WATER AND AGED AT 300 DEG. FAHR. FOR 8 HR.

Quenching Temperature, Deg. Fahr.	Ultimate Tensile-Strength, Lb. per Sq. In.		Elongation in 2 In., Per Cent		Brinell Hardness		Specific Gravity	
	Aged Immediately	Aged after 24 Hr.[13]	Aged Immediately	Aged after 24 Hr.[13]	Aged Immediately	Aged after 24 Hr.[13]	Aged Immediately	Aged after 24 Hr.[13]
875	30,840	29,930	1.2	1.3	86	81	2.737	2.735
900	31,300	30,780	1.2	1.5	81	81	2.728	2.727
925	34,840	35,120	1.0	1.5	92	93	2.726	2.725
950	37,300	36,360	1.3	1.5	92	90	2.731	2.727
975	44,480	41,080	1.8	1.5	103	102	2.744	2.733
1010	34,430	29,250	1.0	1.0	97	91	2.717	2.720
1025	15,610	17,810	0.5	0.5	67	63	2.660	2.658

[12] Remelted from Melt No. 2437, the composition of which is given in Table 2.

[13] The specimens from which these values were obtained were aged at room temperature for 24 hr. after quenching and were then aged at 300 deg. fahr. for 8 hr.

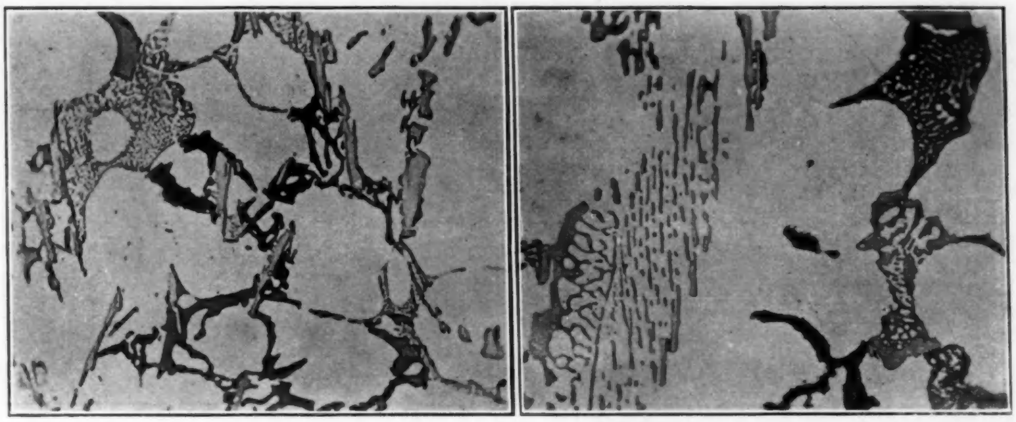

FIG. 9—PHOTOMICROGRAPHS, MAGNIFIED 500 DIAMETERS, SHOWING CHARACTERISTIC STRUCTURES OF AS-CAST AND HEAT-TREATED SPECIMENS OF THE ALLOY
The Photomicrograph at the Left Is of the Average Structure of an Unetched As-Cast Specimen, while That at the Right Was Etched with a 25-Per Cent Aqueous Solution of Nitric Acid for 30 Sec. at 158 Deg. Fahr. and Was Quenched in Cold Water. In the Former the Compound $CuAl_2$ Is Shown Intimately Mixed with the Compound Mg_2Si as a Filagree Structure. The Halftone in Both Photomicrographs Represents What Is Probably a Ternary Compound of Copper, Nickel and Aluminum. Primary Mg_2Si, as Distinguished from That Associated with $CuAl_2$, Is Shown Black. The Constituents Shown Light in the Photomicrograph at the Left Are $NiAl_3$ and the Iron Bearing Constituents. A Further Etching with a 10-Per Cent Aqueous Solution of Sodium Hydroxide for 40 Sec. Renders Their Identification Possible. In the Photomicrograph at the Right Can Be Seen the Characteristic Form of $NiAl_3$ in the Upper Field, While the Mg_2Si and the $CuAl_2$ Appear Dark, Since the Former Is Dissolved Out and the Latter Is Turned a Deep Brown by the Nitric Acid

that aging at 300 deg. fahr. immediately after quenching is more desirable.

It is thought that the ultimate tensile-strength of 45,000 lb. per sq. in. is not the maximum obtainable for the prolonged soaking at 975 deg. fahr., quenching in water and aging at 300 deg. fahr. From analogy with results obtained with sand-cast duralumin similarly and more extensively heat-treated, it is anticipated that by aging at 300 deg. fahr. for 24 hr. the ultimate tensile-strength of the aluminum-copper-nickel-magnesium alloy can be made to attain a figure of over 50,000 lb. per sq. in. and the Brinell hardness a value of about 110.

The strength of the aluminum-copper-nickel-magnesium alloy at 600 deg. fahr. in either the sand-cast or the heat-treated condition is indeed worthy of consideration. While the results included in Table 8 represent but two tests or six specimens at elevated temperature, they show consistently that the alloy at 600 deg. fahr., whether in the cast or the treated condition, has tensile properties at least the equal of those for the alloy in the corresponding condition and tested at room temperature. The heat-treated alloy at 600 deg. fahr. had an ultimate tensile-strength of 29,960 lb. per sq. in. and an elongation of 1.2 per cent; while the alloy as cast and at 600 deg. fahr. gave corresponding figures of 26,450 lb. per

TABLE 8—PHYSICAL PROPERTIES OF AS-CAST AND HEAT-TREATED SPECIMENS OF THE ALLOY[14]

Condition of Test-Specimen	As Cast		Heat-Treated[15]	
Test Temperature, deg. fahr.	70	600	70	600
Ultimate Tensile-Strength, lb. per sq. in.	25,230	26,450	29,430	29,960
Elongation in 2 In., per cent	0.8	1.5	0.5	1.2
Brinell Hardness at 70 Deg. Fahr. after Test	70	72	86	90

[14] Melt No. 1853 and its remelt. See Table 2 for chemical composition.
[15] Heated at 940 deg. fahr. for 3 hr. and quenched into and aged in boiling water for 3 hr.

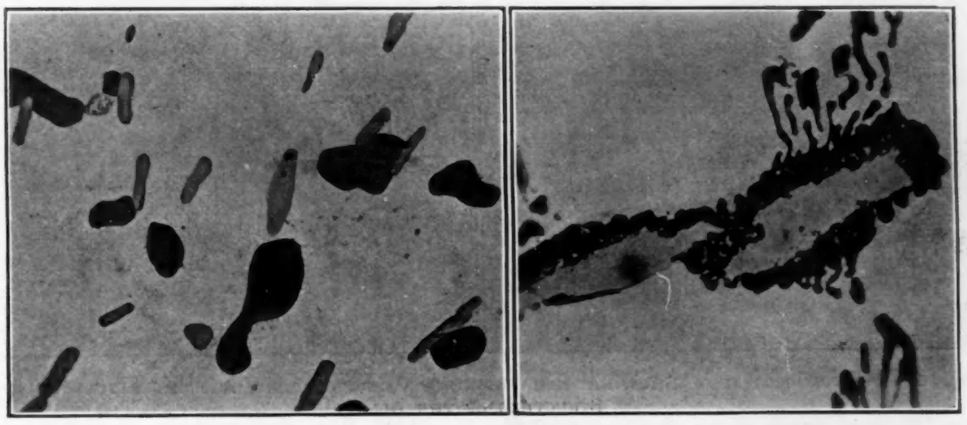

FIG. 10—TWO OTHER PHOTOMICROGRAPHS SHOWING THE CHARACTERISTIC STRUCTURE OF THE ALLOY
The Photomicrograph at the Left Shows How This Alloy Looks after Being Heated for 96 Hr. at 1010 Deg. Fahr., Quenched in Cold Water and Subsequently Etched with a 25-Per Cent Aqueous Solution of Nitric Acid and Quenched in Cold Water. The Compound $NiAl_3$ Is Represented by the Lighter Spots and the Ternary Compound by the Dark Ones. The Tendency of These Constituents To Ball Up and Coagulate Is Clearly Brought Out. Evidence That the Ternary Constituent Is a Reaction Product Is Shown in the Photomicrograph at the Right Where a Particle That Was Initially $NiAl_3$ but That Has Been Transformed at Its Rim to the Ternary Constituent by Reaction with the $CuAl_2$ in the Aluminum Solid Solution Can Be Seen. The Magnification in Both Cases Is 500 Diameters

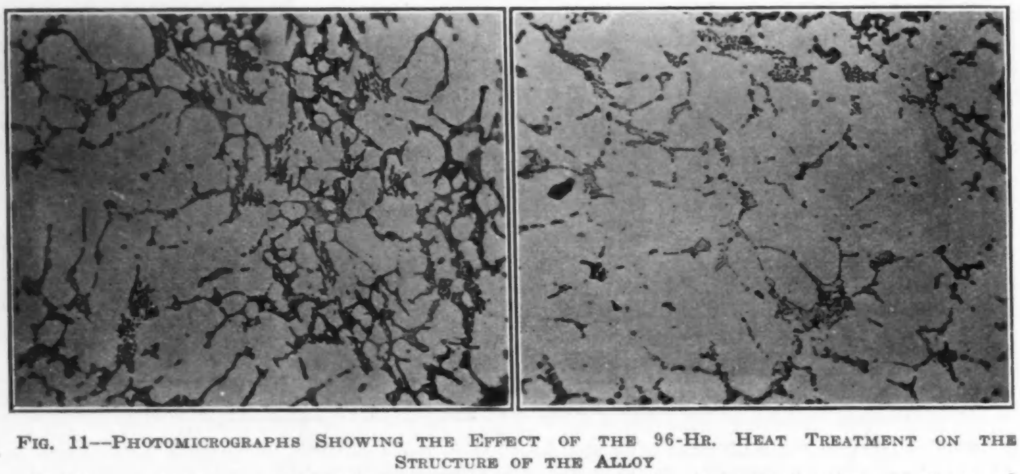

FIG. 11—PHOTOMICROGRAPHS SHOWING THE EFFECT OF THE 96-HR. HEAT TREATMENT ON THE STRUCTURE OF THE ALLOY

The View at the Left Is a Magnification of 100 Diameters of the Average Structure as Cast and That at the Right Is of a Specimen That Was Heated at 950 Deg. Fahr. for 96 Hr., Quenched in Cold Water and Then Reheated to, or Aged at, 300 Deg. Fahr. for 8 Hr. The Magnification in This Case Is Also 100 Diameters

sq. in. and 1.5 per cent, which would indicate that the alloy develops its optimum properties in the heat-treated condition. Somewhat similar results for the chill-cast alloy, tested at 482 deg. fahr., however, have already been obtained.[16]

The results discussed in the last paragraph are very different from the ones obtained by the British investigators in their work on the sand-cast aluminum-copper-nickel-magnesium alloy. Their curve[17] shows that in the chill-cast condition the *Y* alloy retains most of its original strength at temperatures up to about 480 deg. fahr., at which temperature it loses about 5 per cent of its initial strength, but at 570 deg. fahr. it forfeits about 17 per cent and at 660 deg. fahr. about 53 per cent of its original strength. The same curve throughout indicates much higher percentages of elongation than those obtained at McCook Field.

It would seem, then, from the general characteristics and especially from the standpoint of the elevated-temperature tests conducted at McCook Field, that the sand-cast aluminum-copper-nickel-magnesium alloy has a distinct future as a piston and cylinder-head alloy. It casts well, is easily and economically heat-treated, has excellent physical properties at normal and elevated temperatures and is known to possess a high thermal conductivity of about 0.36.[c]

METALLOGRAPHY

In the as cast condition the microstructure of this alloy is very complex. There are at least five constituents in evidence in Fig. 9 which illustrates the average structure unetched at the left and at the right etched with a 25-per cent aqueous solution of nitric acid for 30 sec. at 158 deg. fahr. followed by quenching in cold water. In the photomicrograph at the left the compound $CuAl_2$ is shown intimately mixed with the compound Mg_2Si. This filigree structure has also been observed in other alloys containing both copper and magnesium. The constituent shown in half tone in Fig. 9 is probably the ternary compound of copper, nickel and aluminum described by K. E. Bingham and J. L. Haughton in their

[16] See the 11th Report to the Alloys Research Committee of the Institution of Mechanical Engineers, p. 43.

[17] See the 11th Report to the Alloys Research Committee of the Institution of Mechanical Engineers, p. 29.

[c] See the 11th Report to the Alloys Research Committee of the Institution of Mechanical Engineers, p. 38.

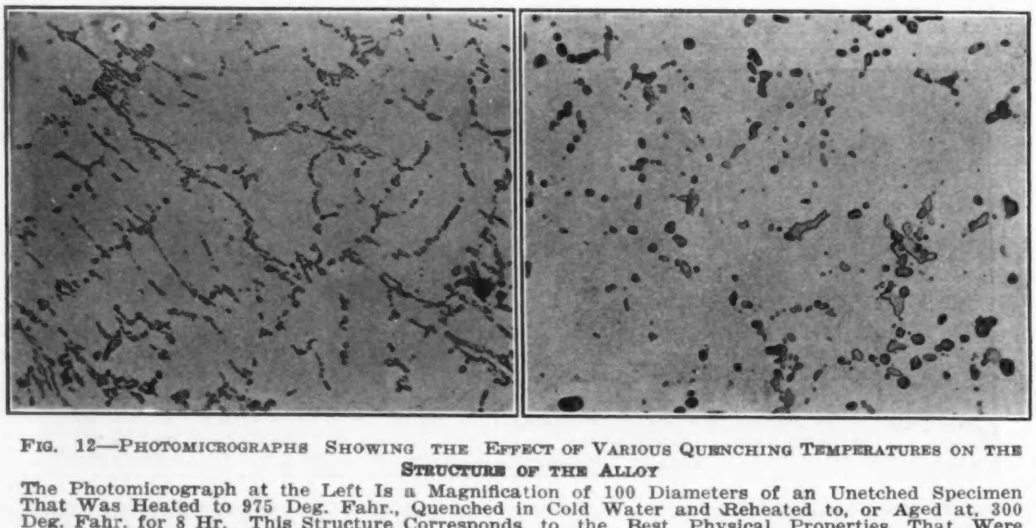

FIG. 12—PHOTOMICROGRAPHS SHOWING THE EFFECT OF VARIOUS QUENCHING TEMPERATURES ON THE STRUCTURE OF THE ALLOY

The Photomicrograph at the Left Is a Magnification of 100 Diameters of an Unetched Specimen That Was Heated to 975 Deg. Fahr., Quenched in Cold Water and Reheated to, or Aged at, 300 Deg. Fahr. for 8 Hr. This Structure Corresponds to the Best Physical Properties That Were Secured. Here the $NiAl_3$ and the Ternary Compound Have Just Begun To Spheroidize and Coagulate and Occur Chiefly as Stringers along the Grain Boundaries. The Specimen, from Which the Photomicrograph at the Right Was Reproduced, Was Heated to 100 Deg. Fahr. for 96 Hr., before Being Quenched in Cold Water and Was Subsequently Reheated to, or Aged at, a Temperature of 300 Deg. Fahr. for 8 Hr. This Specimen Was Etched with a 20-Per Cent Aqueous Solution of Nitric Acid for 30 Sec. and Was Quenched in Cold Water. It Will Be Noticed from This Photomicrograph, Which Is Also Magnified to 100 Diameters, That the Processes of Spheroidization, Coagulation and Diffusion Have Advanced Considerably

paper before the Institute of Metals entitled the Constitution of Some Alloys of Aluminum with Copper and Nickel[19]. It is blue gray in color and resembles free silicon both in color and in its resistance to attack by the etching reagents commonly used for aluminum and its alloys. Primary blue Mg_2Si, as distinguished from that associated with the $CuAl_2$, is shown black in the photomicrographs. The constituents shown light in the photomicrograph at the left are $NiAl_3$ and the iron-bearing constituents. These cannot be distinguished from one another in the unetched specimen except when $NiAl_3$ occurs in the characteristic form shown in the upper field of the photomicrograph at the right. Further identification is made possible by etching with a 10-per cent aqueous solution of sodium hydroxide for 40 sec. The $NiAl_3$ is colored brown, while the iron constituents remain unattacked. In the etched specimen both the Mg_2Si and $CuAl_2$ appear dark, since the latter is turned a deep brown by the nitric acid etch and the Mg_2Si is dissolved out. $NiAl_3$ and the iron constituents are not attacked.

The characteristic structure, magnified 500 diameters, of this alloy heated for 96 hr. at 1010 deg. fahr. and quenched in cold water is shown in Fig. 10 at the left. The compound $NiAl_3$ is shown light and the ternary constituent dark. The form in which these occur shows very well the tendency for the above constituents to ball up and coagulate. Practically all of the $CuAl_2$ and Mg_2Si have been absorbed during the annealing operation, and evidence that the ternary constituent is a reaction product is shown in right half of the illustration, where a particle that was initially entirely $NiAl_3$, but that has been transformed at its rim to the ternary constituent by reaction with the $CuAl_2$ in the aluminum solid solution can be seen.

The effect of 96-hr. treatment at various temperatures on the structure of this alloy is shown in Figs. 11 and 12. The structure that corresponds to the best physical properties, and was obtained at 975 deg. fahr., is shown in Fig. 12 at the left. Here the $NiAl_3$ and ternary constituent have just started to spheroidize and coagulate and occur mostly in stringers along the grain boundaries. The photomicrograph at the right of Fig. 11, which depicts the structure when heated at 950 deg. fahr., shows a very slight degree of spheroidization; while the structure shown in Fig. 12 at the right which has been heated to 1010 deg. fahr. indicates that the processes of spheroidization, coagulation and diffusion have advanced very considerably. It is apparent that the alloy must at least be heat-treated at a temperature and for such a length of time as will initiate spheroidization. Treatment beyond this point or at temperatures much in excess of 975 deg. fahr. produces structures that cannot be associated with the best physical properties.

It is to be seen that the microscope has a distinct field as an aid in the attainment of the best results from this alloy.

[19] See the *Journal of the Institute of Metals*, vol. 29, p. 89.

Summary

(1) The alloying, casting, heat-treatment, physical properties and metallography of a sand-cast aluminum-copper-nickel-magnesium alloy that can be easily handled and is suitable for use in aircraft engine construction are described.

(2) The average physical properties of the alloy in the as cast condition are as follows:

Ultimate tensile-strength, lb. per sq. in.	25,030
Elongation in 2 In., per cent	0.7
Brinell Hardness	74

(3) The most economical heat treatment is as follows:
Heat at 975 deg. fahr. ± 10 deg. fahr. for 5 hr.
Quench in boiling water or air
Age at 250 deg. fahr. ± 50 deg. fahr. for 16 hr.
The average physical properties resulting from this treatment are:

Ultimate Tensile-Strength, lb. per sq. in.	37,270
Elongation in 2 In., per cent	1.1
Brinell Hardness	93
Specific Gravity	2.725

Heating at 75 deg. fahr. ± 10 deg. fahr. for 96 hr., quenching in cold water and aging at 300 deg. fahr. for 8 hr., produced an average ultimate tensile-strength of 44,480 lb. per sq. in., with a 1.8-per cent elongation in 2 in. and a Brinell hardness of 103

(4) For comparison, the following results represent the average physical properties of two well-known light alloys, determined from the same type of test-specimen as the alloy under investigation:

Alloy	8 Per Cent Copper, 92 Per Cent Aluminum	10 Per Cent Copper, 90 Per Cent Aluminum
Condition	As Cast	As Cast
Ultimate Tensile-Strength, lb. per sq. in.	20,670	20,600
Elongation in 2 In., per cent	2.00	1.20
Brinell Hardness	52	58
Specific Gravity	2.83	2.84

(5) Tensile tests at 600 deg. fahr. indicate that this alloy has the remarkable property of being slightly stronger than at ordinary temperatures

(6) Photomicrographs of the as-cast and the heat-treated alloy are shown

In conclusion, we wish to express our sincere appreciation of the interest S. D. Heron has shown in this work, and to thank J. B. Johnson for suggestions and for permission to publish these results.

HEADQUARTERS AND FIELD

It is a great mistake for presidents and other leading executives, and also sales managers, of large organizations having branches or offices throughout the Country to chain themselves to their desks at headquarters and send out rigid instructions to those in charge of its distant branches and offices. A policy or a regulation that may fit ideally the city in which the head offices are located may not fit a city or town in the South or in the West or in the sparsely populated States lying between the Pacific and the Middle West. Managers of local branch establishments complain bitterly that, instead of being helped by those at headquarters, they repeatedly are handicapped. Conditions differ in different sections, in different States, in different cities, in different communities. One cannot avoid the conclusion that the tendency to settle everything at headquarters without consultation with out-of-town representatives is too great.

Men who manage organizations having nationwide ramifications had better take cognizance of this dissatisfaction and start corrective measures, either by traveling to see things for themselves on the spot or by calling their representatives into conference at various central points or at headquarters.—B. G. Forbes.

Radiation Characteristics of the Internal-Combustion Engine

By Thomas Midgley, Jr.[1] and H. H. McCarty[2]

Annual Meeting Paper *Illustrated with* Drawings and Photographs

RADIATION, although the subject of study for many years, is not yet thoroughly understood. The investigations of von Helmholtz 30 years ago showed that from 10 to 20 per cent of the total heat of combustion is due to radiation; but flames burning in the atmosphere show different characteristics from those subjected to a change of density in a combustion-chamber and the same conclusions do not apply. The possibility of a non-luminous flame's causing loss of heat during and after combustion was first noted by Professor Callendar in 1907. The principal theory as to the source of radiation is that it is due to the vigorous vibration of the gas molecules formed on combustion, and that, like the high-frequency radiations producing light, it is caused by chemical rather than thermal action. It has been shown that radiation emanates almost wholly from the carbon dioxide and the water molecules.

As the total heat given off when a mixture burns in a gas engine is divided into two forms, (*a*) that due to conduction, and (*b*) that due to radiation, special instrumentation was necessary for properly observing them. This consisted of a stroboscope by which the duration of the luminous flame, the characteristic differences in color and brightness at different phases of combustion and the variations of the flame with changes in the quality of the mixture could be noted, and a thermopile for measuring the changes in the radiation of the flame. The investigation covered four fuels, namely, kerosene, kerosene plus 3 cc. of lead per gallon, a high-test gasoline that was free from detonation and a new Navy gasoline that contained 3 cc. of tetraethyl lead per gallon. Varying the mixture-ratio, detonation and the distribution of the radiant energy was found to affect the amount of radiant energy produced. It decreases as the mixture-ratio is leaned, or enriched to a comparatively low value; but it increases if the mixture-ratio is made very rich and may even be greater than the maximum occurring at the theoretically correct mixture-ratio; and it varies with the pressure. The conclusion reached is that the radiation produced during internal combustion is a function of the chemical reaction involved to a much greater extent than are merely the temperatures of the gases.

AN extensive study of radiation has been made by a number of investigators. In spite of this fact, the phenomenon is far from being thoroughly understood. This is especially true insofar as it applies to the internal-combustion engine. In presenting this paper no attempt will be made to explain the phenomena with which it deals nor to give an explanation of the results obtained. The object of the paper is to present data showing how radiation varies with the changes in the character of combustion.

Results of Early Study of Radiation

In 1890 Robert von Helmholtz studied radiation from gas flames, both luminous and non-luminous, and made some determinations of the relation of radiation to the total heat of combustion of a gas. His results showed that from 10 to 20 per cent of the total heat of combustion is due to radiation. But flames burning in the atmosphere show different characteristics when they are subjected to a change of density, as in a combustion-chamber. Hence, it would be hard to apply von Helmholtz' conclusions directly to the gas-engine explosion-flame.

Although von Helmholtz 30 years ago showed that a non-luminous flame radiates large amounts of heat, its possible importance in causing loss of heat during and after combustion and in determining the heat-flow in an internal-combustion engine does not appear to have been realized until about 1907. At that time Professor Callendar, in a paper entitled On the Measurement of Temperatures in the Cylinder of a Gas Engine[3] and read before the Royal Society, first called attention to its significance in this connection.

Radiation, Its Origin and Nature

Some difference of opinion seems to exist as to the source of the radiation from the flame, that is, as to what causes the radiation of heat. Many experiments have been conducted and numerous theories have been advanced in an effort to settle this question.

The principal theory so far advanced is that the radiation produced is due to the vigorous vibration of the gas molecules formed on combustion; or, in other words, that this radiation, like that of high-frequency radiation, which gives luminosity, is due to chemical action rather than to purely thermal causes.

Another question is, what part of the burnt gases produces this radiant energy? Experiments carried out by Julius and R. von Helmholtz with gas flames at atmospheric pressure showed that the radiation is due almost wholly to the molecules of carbon dioxide and water. Julius examined the spectrum of the flame by a rock-salt prism, and found that in all flames producing both carbon dioxide and steam most of the radiation was concentrated into two bands having wave lengths respectively of 4.4 and 2.8 μ. He found further that in a pure hydrogen flame the 4.4-μ band disappeared completely, but the other remained; and that in a pure carbon monoxide flame the 2.8-μ band disappeared and the other remained.

A confirmation of these results was furnished in the work of R. von Helmholtz, to which reference has been made above, in which he found that the radiation originated in the vibration of the carbon dioxide and the steam molecules. He stated that the life of one of these steam molecules as a radiating body extends from the moment of formation to the time when its vibration energy has been destroyed by radiation and by collision with colder molecules.

In the gas-engine cylinder, as well as in the flame experiments, we are usually concerned with flames in which an excess of air is present. Such a mixture,

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[2] Jun. S.A.E.—Mechanical research engineer, General Motors Research Corporation, Dayton, Ohio.

[3] See *Journal of the Royal Society*, vol. 80, p. 57.

burnt at atmospheric pressure, gives an almost non-luminous flame; while in the engine, there is no reason to suppose that radiation in the gas-engine cylinder

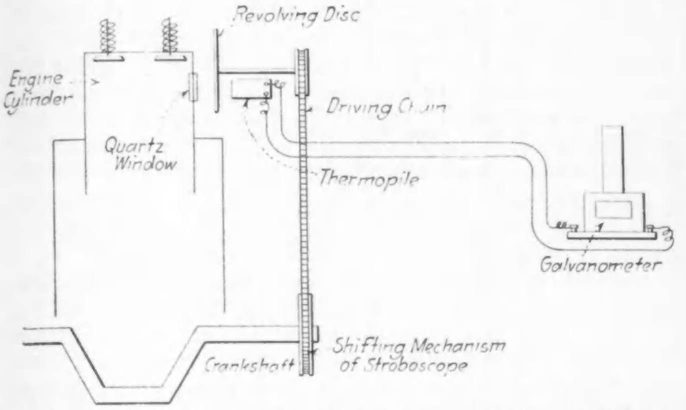

FIG. 1—GENERAL ARRANGEMENT OF THE APPARATUS USED IN OBTAINING THE RADIATION CARDS
This Illustration Is Only Diagrammatic; the Actual Arrangement of the Engine and the Apparatus Is Shown in Fig. 2

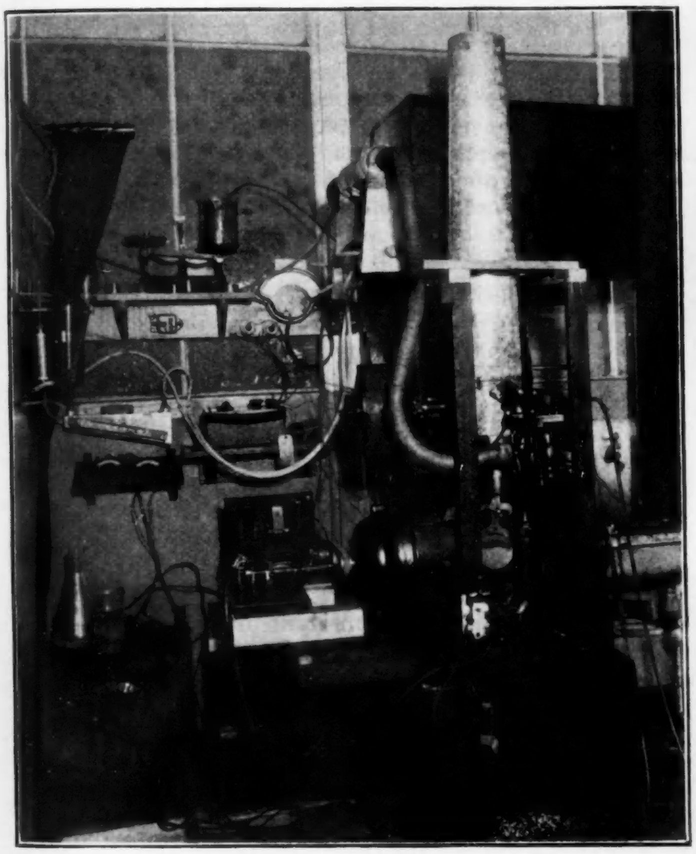

FIG. 2—GENERAL VIEW OF THE ENGINE AND THE AUXILIARY APPARATUS
The Radiation Tests Described in the Paper Were Made on a $\frac{3}{4}$-Kw. Single-Cylinder $2\frac{1}{2}$ x 5-In. Air-Cooled Engine Directly Connected to a 32-Volt Direct-Current Generator. The Only Changes Made in the Engine Were the Substitution of a Standard Plain-Tube Carbureter for the Mixing-Valve and the Locating of the Spark-Plug Perpendicularly to the Line of Sight of the Window

differs materially, as regards its quality or origin, from that emitted by an open flame.

NECESSITY FOR FURTHER STUDY

The total heat given off when the mixture in a gas engine burns is known to be divided into two forms, (*a*) that due to conduction and (*b*) that due to radiation. The heat of conduction is due to the contact of hot gases with the cylinder walls, which act as a medium for the

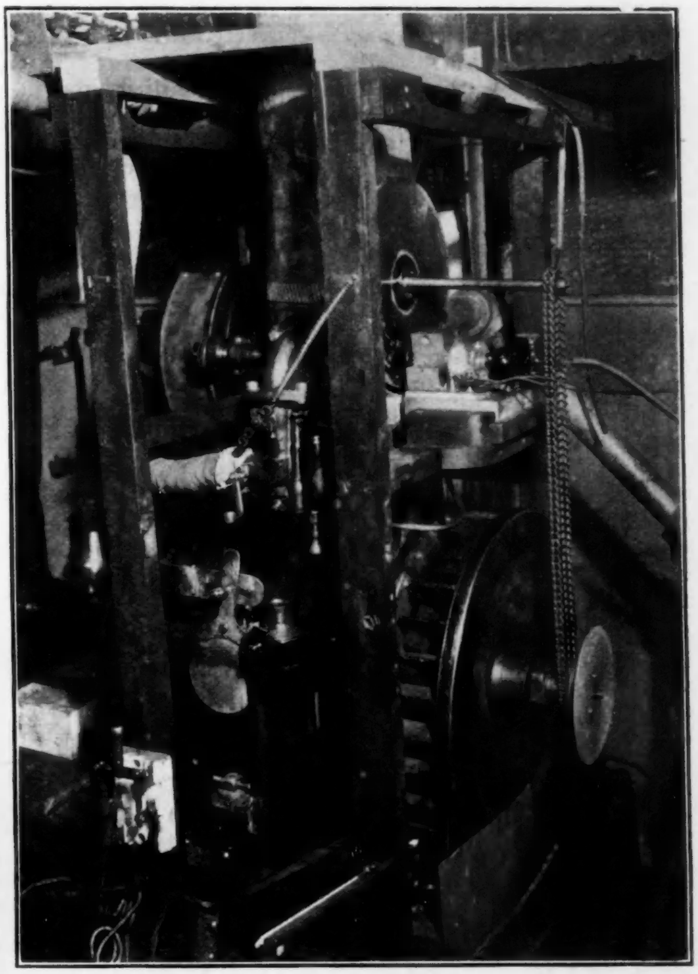

FIG. 3—THE STROBOSCOPE WITH THE THERMOPILE MOUNTED IN PLACE
The Stroboscope Attachment with the Thermopile Was Located in Front of a Quartz Window Measuring 1 In. in Diameter in the Wall of the Combustion-Chamber. Quartz Was Used, Since It Will Pass the Infra-Red Radiations and Glass Does Not. To Prevent the Thermopile, Which Was Constructed of Copper-Constantin Metal, from Being Affected by the Heat of Conduction, It Was Mounted in an Evacuated Tube

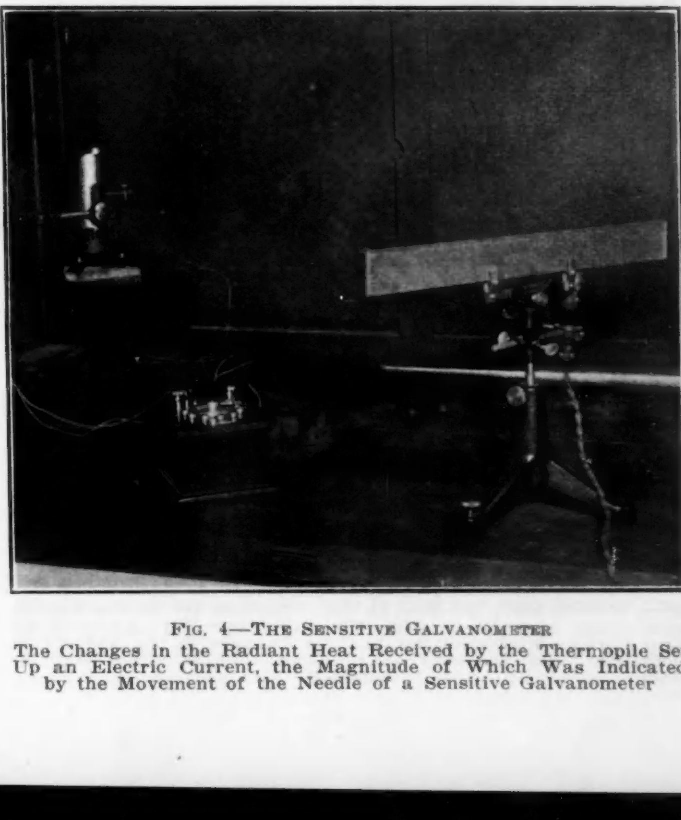

FIG. 4—THE SENSITIVE GALVANOMETER
The Changes in the Radiant Heat Received by the Thermopile Set Up an Electric Current, the Magnitude of Which Was Indicated by the Movement of the Needle of a Sensitive Galvanometer

transfer. Radiation propagates in precisely the same way as light propagates and is converted into heat when it strikes the cylinder walls.

For the proper study of this phenomenon instrumentation is necessary. The various types of indicator that have been used so far for studying internal combustion give only an external picture of the physical effects and throw no light upon what is happening otherwise. With this idea in mind, an effort has been made to devise some means for studying the radiation effects occurring during combustion.

Apparatus has been in use that allows the observer to look into the combustion-chamber while the engine is operating. This consists simply of a window in the wall of the combustion-chamber. Its use is very satisfactory in studying variations in flame color due to changes in the quality of combustion. But since, at an engine speed of 1000 r.p.m., the entire combustion takes place in 0.03 sec., it is possible by this means to see only the predominant color of the flame during the cycle.

In this work, however, it was believed necessary to observe the stages of burning during the cycle. The stroboscope, an apparatus designed to expose the window only at the desired point of the cycle, was used for this purpose. By means of the stroboscope it was possible to observe the duration of the luminous flame, the characteristic differences in its color and its brightness at different phases of combustion and the variations with changes in the quality of the mixture.

With the stroboscope it was possible to get only a mental picture of the combustion, so some means was needed to measure the changes in the radiation of the

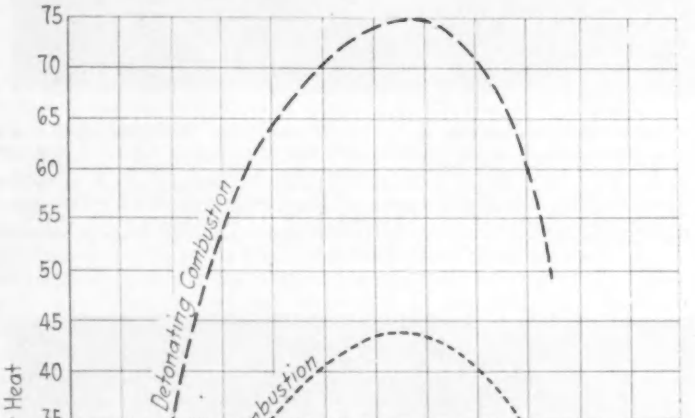

FIG. 5—CURVE SHOWING THE EFFECT OF THE CHANGE IN THE MIXTURE-RATIO ON THE RADIANT HEAT WITH VARIOUS TYPES OF COMBUSTION

These Results Were Obtained as Total Readings by Eliminating the Stroboscope from the Set-Up. The Carbureter Was Adjusted To Give Various Mixture-Ratios and the Changes in the Amount of Radiation Were Observed as Galvanometer Deflections and So Recorded

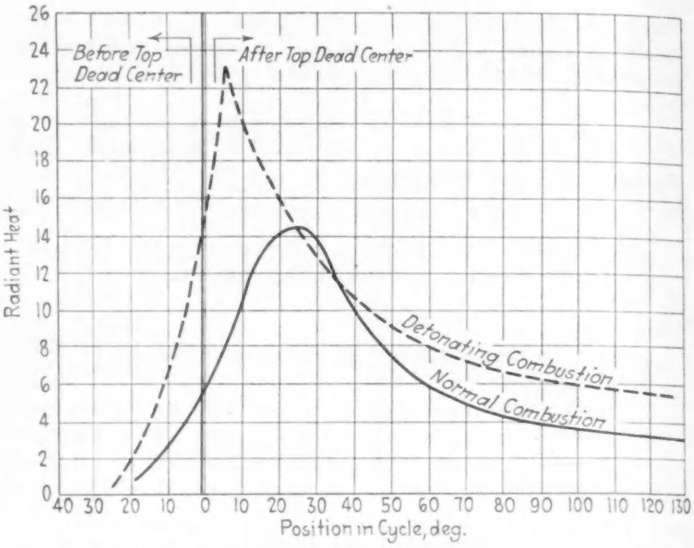

FIG. 6—RADIATION CARDS SHOWING THE CHANGE IN THE RADIANT HEAT WITH NORMAL AND DETONATING COMBUSTION

In This Illustration and in Fig. 5 Detonating Combustion Refers to That of a Kerosene That Detonated Decidedly and Normal Combustion Refers to That of a High-Test Gasoline That Was Free from Detonation

flame during the period of combustion. A thermopile connected with a galvanometer was the instrument used for indicating these changes. The thermopile consisted of a series of thermocouples, made of very fine wire, that were extremely sensitive to heating effects.

DESCRIPTION OF APPARATUS

A ¾-kw. Delco-Light engine was used for making all the determinations. This is a single-cylinder air-cooled engine, having a 2½-in. bore and a 5-in. stroke, and is directly connected with a 32-volt direct-current generator. The engine was standard in every way except that the mixing-valve was replaced by a standard plain-tube carbureter and the spark-plug was located perpendicularly to the line of sight of the window. Fig. 1 is a diagrammatic sketch of the apparatus showing the set-up as used. Fig. 2 is a general view of the plant equipped with the necessary apparatus for the determinations. Fig. 3 shows the stroboscope attachment, with the thermopile placed in front of the window. The window in the combustion-chamber was 1 in. in diameter and was made of quartz, since quartz passes the infra-red radiations that glass does not.

The stroboscope consisted of a disc, rotated at camshaft speed and having a radial slot 1-32 in. wide. The disc was driven by a chain from a planetary transmission attached to the crankshaft, which made it possible to change the angularity of the disc with respect to the crankshaft.

The thermopile was obtained from the Bureau of Standards, and was constructed of copper-constantin metal. In order that it might not be affected by the heat of conduction, it was mounted in an evacuated tube. The changes in the radiant heat in the thermopile were recorded on a sensitive galvanometer. The arrangement of this apparatus is shown in Fig. 4.

The purpose of the investigation was to determine the variations in radiation from the flame that occur in the internal-combustion engine as they are affected by mixture-ratio, detonation and the distribution of this radiant energy. No attempt has been made to obtain quantitative readings, since at best such determinations would be difficult to make and of questionable value.

Variation of Radiation With The Mixture-Ratio and Time

Fig. 5 shows the results of determining the relation of radiation and mixture-ratio. These were obtained as total readings by eliminating the stroboscope from the set-up. The carbureter was adjusted to give various mixture-ratios, and the changes in the amount of radiation were observed as galvanometer deflections and were so recorded. It will be observed that these values are the maximum at approximately the theoretically correct mixture-ratio. The four fuels investigated included a kerosene that detonated decidedly and is recorded in Fig. 5 as "detonating combustion"; kerosene plus 3 cc. of lead per gallon, recorded as "doped-fuel combustion," the detonation in this case not having been entirely eliminated; a high-test gasoline that was free from detonation, recorded as "normal combustion"; and new Navy gasoline, plug 3 cc. of tetraethyl lead, recorded as "ethyl gasoline." It will further be observed that the amount of radiant energy produced within the engine decreases as the mixture-ratio is either leaned, or enriched to a comparatively low value. However, if the mixture-ratio is made extremely rich, so rich in fact that it could not be accurately determined and therefore is not recorded, the radiation will again increase; and it has been observed to be even greater than the maximum occurring at theoretically correct mixture-ratios. This is no doubt due to the liberation of free carbon under these conditions.

Fig. 6 records the results observed by using the stroboscope and compares the radiation during detonating combustion and normal combustion. It should be noted that, in general, the radiation varies approximately with the pressure, as disclosed by pressure-time indicator-cards.

In the case of detonating combustion it is felt that the maximum, as recorded, is by no means the true maximum occurring within the engine cylinder. Although the accuracy of the stroboscope can be vouched for, the phenomenon of detonation itself is not regular in its reoccurrence, but varies over 20 deg. of flywheel travel; and since the results obtained are integrated mean values, it will readily be understood that the maximum recorded, occurring between 0 and 20 deg., is produced by detonation that occurs sometimes a little ahead of, sometimes a little after the apparent maximum position.

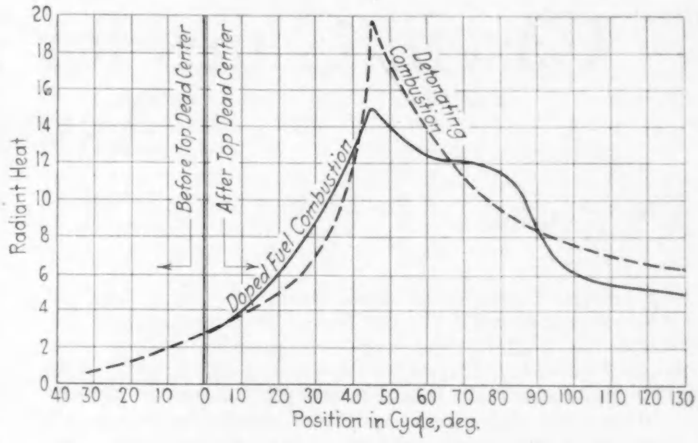

Fig. 7—Radiation Cards Showing the Effect of Doped Fuel on Radiant Heat

In This Illustration and Also in Fig. 5 the Doped Fuel Combustion Refers to That of a Kerosene to Which 3 cc. of Lead Was Added per Gallon. The Detonating Combustion Refers to That of the Same Kerosene without the Lead

From other observations that have been previously published it is felt that the real maximum should be represented as a straight line approximately three times the height of the diagram given.

Fig. 7 yields data that, perhaps, are of the greatest value disclosed by this work. The peculiar curve recorded as "doped-fuel combustion" is typical of all runs made in which anti-knock materials were used in the fuels. A variety of anti-knock materials were investigated, all yielding practically identical results.

Conclusion

The work hereinbefore described leads to the necessary conclusion that the radiation produced during internal combustion is a function of the chemical reaction involved to a much greater extent than are merely the temperatures of the gases, although these unquestionably play a marked part. It is entirely possible that the high radiations recorded during detonation are as much a function of gas temperatures as they are of any difference in the chemical reactions involved.

The curious behavior of a fuel containing anti-knock material is yet to be explained, no apparent explanation being at hand.

PAVEMENT OF STATE HIGHWAYS TRUE ECONOMY

F. R. WHITE, chief engineer of the Iowa State Highway Commission, recently pointed out that the results of tests conducted by the Commission indicate that on an earth road traffic gets 14 ton-miles per gal. of gasoline; on a gravel road, 21 ton-miles; and on a concrete pavement, 31 ton-miles. With gasoline costing 24 cents per gal., the fuel costs 1.70 cents per ton-mile on an earth road, 1.15 cents per ton-mile on a gravel road and 0.77 cents per ton-mile on a concrete pavement.

Applying these figures to actual traffic counts made on the Lincoln Highway just east of Ames, Iowa, where it was found that the total daily traffic amounted to 1232 tons on a gravel road, Mr. White points out that if the road were paved, an obvious saving of 0.38 cents per ton-mile, or a daily saving of $4.78 per mile, would result. This amounts to $1,746 per mile per year.

The average cost per mile of maintaining the gravel roads in Iowa was $803 in 1922, while the average cost of maintaining pavements was $89 per mile. Accordingly, the saving in the cost of maintenance between the average mile of gravel road and the average mile of paved road was $714. This amount, added to the $1,746 per mile saved in the fuel consumed, would make a total yearly saving of $2,460 per mile per year on the heavily traveled roads.

The 18-ft. concrete road that Iowa is now building costs $26,400 per mile on the average. The interest on this investment at 5 per cent amounts to $1,320 per mile the first year. By paying for a portion of the road each year, however, the average interest would be only one-half of the total interest for the first year or $660. Deducting this amount from the $2,460 saving per mile per year in fuel and maintenance cost, gives an average saving of $1,800 per mile per year to be paid on the cost of the road. Thus the savings completely pay for the pavement in 15 years.—*Lincoln Highway Forum.*

Casein Glues for Automobile-Body Assembly

By W. A. Henderson[1]

Annual Meeting Paper

CASEIN glue is prepared from the solid part of skimmed milk. After it has been precipitated by acids or bacteria the casein is pressed, broken into small particles, trayed, dried, ground and bolted. The complete removal of fats is essential in casein that is to be used for glue. Adding a small percentage of hydrated lime forms calcium caseate, an insoluble compound. Although this tends to harden the glue, it reduces the adhesive power and is very destructive to edged tools. Casein glue sets partly by evaporation and partly by chemical action.

Most casein glues are heavy and spread less readily by hand than does animal glue, but that now being made for the automobile-body trade has overcome this difficulty; when a glue spreader is used, casein glue will cover a greater area than an equal amount of animal glue.

The uncertainty of getting a good joint with animal glue, because of variations of the temperature of the room and of the wood and the composition and freshness of the glue, is obviated in casein glue, which may be mixed at any time in the correct proportions, requires no further attention, yet retains its maximum sticking properties. It may be used at temperatures below freezing on cold wood and the pieces may be allowed to stand for 20 min. before being clamped or screwed. It is highly water-resistant; when applied to a three-ply panel the glue can be boiled without the plies separating. Heat does not weaken the glue but, on the contrary, strengthens it. One of the great advantages of its use in automobile bodies is the fact that it is quickly and easily prepared and thereafter needs no further attention; any portion that is left over at night is poured into the new mix the following morning.

CASEIN is the solid part of skimmed milk. It is precipitated from sweet skimmed milk by one of several acids, such as sulphuric or muriatic, or by milk bacteria. When the precipitation has been thus obtained, the casein is termed "self-cured." After the casein has been precipitated and is still in its wet state, it is known as curd. The curd is placed in a press to squeeze out as much of the water as possible. It is then broken into small particles by a "hog" and "trayed." The trays pass through a humidity-controlled kiln of the tunnel variety, and the curd is dried to a crisp form containing about 4 per cent of moisture. The casein is then ground in specially constructed mills and is bolted through screens of 24 to 50 mesh. The fineness to which it is ground depends upon the purpose for which the finished product is to be used.

Much depends, of course, upon the skill and the care that are used in the many and various processes through which the raw milk must pass before it is suitable for glue purposes and becomes absolutely uniform, which casein glue must be to do the work required of it in body construction. The temperature at which the precipitation is accomplished and the strength and kind of acids used will have a distinct bearing on the solubility. Further, the complete removal of the fats is of the greatest importance in the manufacture of casein for glue, though it is of no importance in casein to be used for other purposes, such as paper coating and the like.

From the casein to the finished product, glue is a question of formulas in which automobile-body builders are not interested nor, I presume, are they deeply interested in its manufacture. Their main interest in the product, and rightly so, is in the advantages it has over animal glue, which they use and have been accustomed to using for so long a time. It is necessary, however, and will, I believe, be interesting to most of you to learn something of the process of manufacture of an article that in my opinion is destined in a short time to become the universal glue for automobile bodies, furniture, airplane woodwork and especially woodwork that is exposed to moisture or heat.

Lime in Casein Glue

Glue must contain a certain percentage of hydrated lime because it produces calcium caserate, which is insoluble. The percentage of lime required is small, but some casein glues contain a high lime-content for the obvious reason that it greatly reduces the cost. The effect of this practice is to reduce greatly the adhesive power of the glue, as lime has no adhesive value but tends to harden the glue when set and is very destructive to edged tools, such as shaping and planing machine knives, saws, and the like. This in the past has been a serious objection that has been raised against some commercial glues; nevertheless, a small percentage of lime is necessary. But if the lime is of the proper kind, and only a very small quantity is used, a casein glue is obtained that is as soft as any hide glue.

Great progress has been made since the war in the manufacture and the use of casein glue. At that time the best known glue was manufactured and sold under the trade name of Certus. I believe it is proper to mention this glue, as it is no longer being manufactured. It was very hard because of an excessive lime-content; it was not uniform and could not be, because the casein used in its manufacture was obtained from many different sources; and its liquid life was short and uncertain.

Casein glue sets partly by evaporation and partly by chemical action. When mixed and ready for use most casein glues are rather heavy and spread less readily by hand than does animal glue, but this is not so with casein glue that is now being manufactured for the automobile-body trade. This glue works just as easily and spreads fully as freely as any good animal glue. When glue spreaders are used casein glue will cover a much greater area than a like amount of animal glue.

Casein versus Animal Glue

I shall now state some of the advantages that casein glue has over animal glue in the building of automobile bodies. As everyone that has ever used animal glue knows, to get a good joint, one that will hold, the temperature of the room in which the work is being done must be correct, the wood must be warm and the glue

[1] Casein Mfg. Co., New York City.

must be hot and fresh, not too thick nor too thin. This is a matter of individual judgment and varies with the person making it. If a man thinks the glue is too thick, he uses his judgment and adds a little water, when, as a matter of fact, the glue may be just right. Another workman will, perhaps, consider the same glue too thin and proceed to add some thick fresh glue to the pot to raise it to his so-called standard, though there is no standard. Every honest workman has his own standard and a dishonest one does not care, but will use any glue, whether it be thick or thin.

By using casein glue these conditions are avoided, because the glue can be mixed at any time, and the correct proportions of water and glue are used. This mixing takes not more than 10 min. after which the glue must stand for 20 min. before using. It is then ready and can be used all day without anything more being done to it, so that individual judgment does not enter at all. Thus you are assured of a glue that will have its maximum sticking qualities throughout the entire day.

To obtain a well glued joint with animal glue, it is not only necessary that the glue be just right, the stock warm and the temperature in the room correct, but also the pieces must be clamped, or screwed, immediately after the glue has been applied. If animal glue is allowed to chill at all, which it does very readily, it is of no value whatever. In using casein glue the temperature may be below freezing, the wood also may be cold and the pieces to which the glue has been applied may be allowed to stand for 20 min. before being clamped or screwed. The results will be as good as if the gluing had been done in a warm room. In short, all conditions are ideal for gluing with casein glue, whereas ideal conditions for gluing with animal glue are almost impossible to obtain in the building of automobile bodies. Even in the summer time, if the windows are raised, the glue is likely to become chilled and rendered useless, or worse than useless, as it is simply a thin sheet of gelatine between the two pieces of wood and is an excellent absorbent of moisture.

Water and Heat-Resisting Qualities

We shall now take up the waterproof qualities of casein glue. Some casein glues are really 100 per cent waterproof and it is almost impossible to soak or boil the joints apart in hot water; but these glues are thick, heavy, and hard on edged tools; but as automobiles are never boiled or kept soaking in hot or warm water for weeks or even days at a time, it is not necessary to use this glue. The glue that is being manufactured for the automobile-body trade is highly water-resistant. I can best describe this quality by stating that it will remain unaffected by any conditions that it will meet in an automobile body. On certain constructions, such as a 3/16-in. three-ply panel, the glue can be boiled without the plies separating.

Still another quality of casein glue that is of the most vital importance in the building of automobile bodies at the present time is its heat-resisting qualities, which are infinitely greater than those of any animal glue I have ever known. I have subjected casein-glued woods to all degrees of heat, up to the point at which the wood becomes charred. Heat does not weaken the glue; in fact, the application of heat greatly strengthens it. I have glued and tested for heat-resistance the following woods: Oak, ash, hard and soft maple, elm, gum, poplar, chestnut and beech. In every instance the glued joint would stand as much heat as the wood. In short, casein glue will stand a heat test of 428 deg. fahr. for 28 consecutive hr., and this is more than the wood will stand. Of course, if the glued joints are tested immediately after taking them from the oven, they will break more readily than if they are allowed to stand for several hours. The reason is, of course, very obvious. The wood, subjected to the excessive heat, has shrunk as much as possible, causing a strain on the glued joint; also, every particle of moisture has been evaporated from the glue. In the course of 24 hr. the wood will absorb moisture and the joint will regain its original strength. This, in my opinion, is one of the greatest advantages that casein glue has over any animal glue. I have never known an animal glue that would not be permanently ruined by being subjected to overheating. The advantages of casein glue in the building of automobile bodies are so many and so great that it will be only a short time, in my opinion, before all body builders will use it exclusively.

First, we shall consider the convenience of preparing casein glue for use. We simply take 1 lb. of powdered glue and sprinkle it into a glue-mixing machine containing 2 lb. of water. This takes from 2 to 5 min. The machine is kept turning for about 5 min. longer and is then shut off. We let the glue stand for 20 min. before using and then go ahead and use it all day without any further trouble. If some is left over at night, it is poured into the new mix the following morning. Just compare this with the work, trouble and care that must be exercised in the preparation of animal glue, with which we all are familiar, and which it is unnecessary for me to explain here. After the casein glue has stood 20 min. it is used in this state all day; no heating, no adding of water; in fact, if left alone, it is foolproof. Animal glue, even after it has been properly cooked, must be kept hot all the time. In keeping it hot, evaporation is continuous, which makes it necessary for the user to add water from time to time and always by guess. One may buy the best possible animal glue, yet never know what results he is actually obtaining from its use.

As a matter of fact, if casein glue were as well known, and if persons were as accustomed to using it as they are to using animal glue, anyone who would undertake to induce them to use animal glue would be considered a fit candidate for the insane asylum, as he would not have one advantage over casein glue to offer them but many serious disadvantages.

Viscosity of Lubricants at High Pressure and Temperature[1]

By Mayo D. Hersey[2]

Illustrated with Chart

THIS paper shows the viscosities of a number of lubricants over a far greater range of pressures than has hitherto been attempted. It also shows how the viscosity varies with the temperature at these high pressures. Such results are of great importance for aircraft-engine lubrication, because the pressures and the temperatures of the oil-film in the connecting-rod and crankshaft bearings, and particularly in the cylinder, may be very much higher than are usually employed in the routine testing of lubricants. The pressures must be at least as high as the explosion pressure, and before scoring of the cylinder walls or abrasion of the piston rings and the bearings can occur, the film pressure in small spots, and these are the important ones, may exceed the shearing or compressive strength of the metal. The corresponding temperature may equal or exceed the fire point of the oil. Although these pressures and temperatures are unknown, it is evidently desirable in comparing and selecting oils, and in correlating oil specifications with engine performance, to have experimental data on the absolute viscosity of all lubricants at the highest pressures and temperatures available.

Ideally it would be desirable to have the complete viscosity-pressure-temperature surface for each oil, or a family of viscosity-pressure curves for a succession of different temperatures up to the fire point of the oil. The results presented in this paper for five typical oils represent a considerable step in the above direction, although a vast amount of work remains to be done.

Relative-viscosity curves for two fixed and three mineral oils, lard, castor, Veedol medium, Texaco medium and Mobiloil A are given in Fig. 1. The temperature range is from about 22 to 100 deg. cent. (71.6 to 212.0 deg. fahr.); the pressure range up to 4000 kg. per sq. cm. (about 57,000 lb. per sq. in.). The ordinate of each curve is the ratio of the absolute viscosity at the stated temperature and pressure to the absolute viscosity at the same temperature but at atmospheric pressure. The term relative viscosity on the diagram means, therefore, the ratio of two absolute viscosities. The results as shown are approximate only, several minor corrections due to the compressibility of the oils not having yet been applied. These corrections are believed to be negligible in comparison with the probable variations between different samples of an oil that is nominally the same.

The apparatus was briefly described when the first results were published in 1916 in a paper[3] entitled Theory of Torsion and Rolling Ball Viscosimeters and their Use in Measuring the Effect of Pressure upon Viscosity. It consists of a rolling ball viscosimeter, of the type invented by Prof. A. E. Flowers,[4] but with suitable modifications for use at high pressure. Temperatures were controlled at first by a steam jacket, later by an electric heating coil with thermocouple measurements and in recent observations have been carried considerably above 100 deg. cent. (212 deg. fahr.). A detailed account of the apparatus and the results is in preparation.

Several years after the first results covering lard and mineral oils with quantitative results to 200 kg. per sq. cm. (2845 lb. per sq. in.) and qualitative results to 500 kg. per sq. cm. (7115 lb. per sq. in.) were published, the problem was taken up by the Department of Scientific and Industrial Research, and results published by J. H. Hyde, of the National Physical Laboratory, on four fixed and four mineral oils over a pressure range of about 1200 kg. per sq. cm. (17,068 lb. per sq. in.), the temperature in all tests being 40 deg. cent. (104 deg. fahr.). The conclusion was reached that the effect of pressure on the viscosity of fixed oils, as a class, is less than on mineral oils.[5]

It will be seen from the curves presented in Fig. 1 that the viscosities have been determined over a pressure range three times as great as that used by Hyde and at varying temperatures. At these pressures and temperatures the supposed distinction between fixed and mineral oils tends to disappear, so that it is an interesting speculation as to what relationship will be found when still higher pressures and temperatures are reached.

The results given here have been carried out for the Special Committee on Lubrication Research of the American Society of Mechanical Engineers.[6] The Bureau of Standards, Harvard University and the Massachusetts Institute of Technology placed facilities at the author's disposal during the course of this work. The methods employed for the control and the measurement of high pressures are due to Prof. P. W. Bridgman, while the greater part of the data shown in the present curves was obtained by the author's assistant, Henry Shore, at the Massachusetts Institute of Technology.

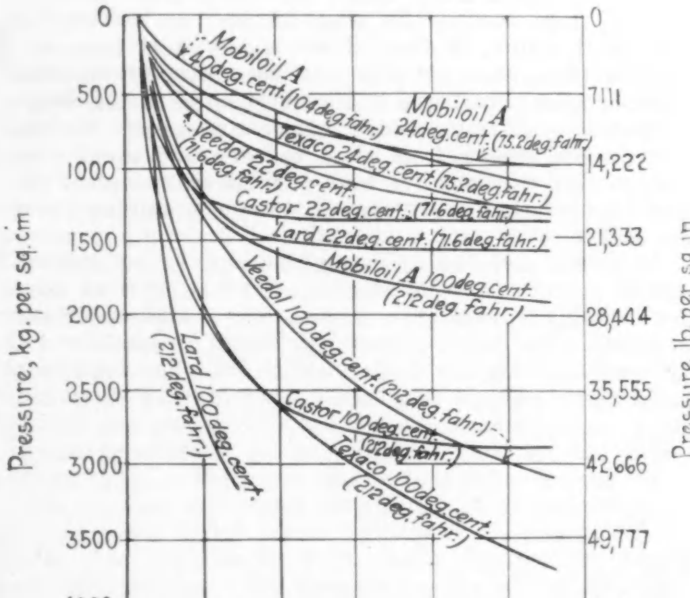

Fig. 1—Relative-Viscosity Curves of Five Different Oils at Three Temperatures

[1] Abstract of a paper presented at the International Air Congress, London, England, June 29, 1923.

[2] Physicist, Bureau of Mines, City of Washington; formerly associate professor of properties of matter, Massachusetts Institute of Technology, Cambridge, Mass.

[3] See *Journal of the Washington Academy of Science*, vol. 6, p. 525.

[4] See *Proceedings of the American Society for Testing Materials*, vol. 14, p. 565.

[5] See *Proceedings of the Royal Society*, vol. 97, A, p. 240; also the 1920 Report of the Lubricants and Lubrication Inquiry Committee of the British Department of Scientific and Industrial Research, p. 88.

[6] See *Mechanical Engineering*, vol. 41, p. 537.

Standards Committee Meeting

THE Standards Committee Division reports as printed in the January issue of THE JOURNAL, a report on Magnet Wire Specifications by the Electrical Equipment Division and a report on Balloon Tires by the Tire and Rim Division that were completed too late for inclusion in that issue of THE JOURNAL were duly considered and acted upon by the Standards Committee at its meeting held in Detroit on Jan. 22 at which Chairman E. A. Johnston presided. The action taken by the Standards Committee was reported to the Council at its meeting in the afternoon of the same day and approved as submitted except that the matter of pneumatic tire sizes for use on 20-in. rims, mentioned in the report of the Tire and Rim Division, was referred back to the Division. The report as approved by the Council was also submitted to the regular Annual Business Meeting of the Society in the evening and was approved and accepted for letter ballot of the Society members for final approval and adoption by the Society.

In casting their letter ballots, which will be counted in accordance with the Standards Committee Regulations 21 days following publication in THE JOURNAL of the action taken at Standards Committee meeting, or on Feb. 25, members should refer to the reports as printed on pp. 37 to 56 inclusive of the January issue of THE JOURNAL and pp. 190 to 194 inclusive of this issue. Each report acted upon is given in this issue of THE JOURNAL by reference only to the title of the report and the page on which it was printed in the January issue of THE JOURNAL except the reports on Magnet Wire and Balloon Tires, which are given in full in this issue. The few changes that were made in the text of reports and such discussion of importance as was had are included in this issue following each subject acted upon.

The session was opened with about 150 members and guests in attendance. After brief introductory remarks by Chairman E. A. Johnston, the Division reports were presented and acted upon in the record time of the morning session only. This was undoubtedly due to increased interest and cooperation in this work of the Society by the many companies and their representatives who have participated in it during the last half year and to a more thorough consideration of the reports before they were published and submitted to the Standards Committee.

ACTION ON DIVISION REPORTS

The accompanying tabulation indicates the action taken on the reports submitted by the several Divisions to the Standards Committee, the Council and the Business Session of the Society. For subjects that were printed in the January issue of THE JOURNAL, page references only to that issue are given. The additional reports that were presented at the Standards Committee Meeting are printed in this issue, as are also notations of such changes as were made in some of the reports. These changes should be noted in the reports published in the January issue of THE JOURNAL.

The report of the Parts and Fittings Division on Compression-Type Fuel and Lubrication Pipe Fittings that was printed on p. 47 of the January issue of THE JOURNAL was reconsidered on the day before the Standards Committee Meeting by members of the Division and representatives of several of the manufacturers of these fittings, and a number of changes made in the tables and the illustrations. The situation with regard to patents in connection with this product, as referred to in the report, was also discussed. It was decided to withdraw the report at this time in order to republish the revised dimensions before the Society adopts them and to refer the matter of the patent situation to the Council for disposition with regard to the policy of the Society in such matters and looking toward making suitable arrangements with the owners of the patents bearing on this subject whereby a free and unrestricted right to manufacture and market fittings of the type proposed for standardization can be secured.

The report of the Screw-Threads Division on Carriage Bolts, printed on p. 54 of the January issue of THE JOURNAL, was withdrawn at the Standards Committee Meeting because it was stated that some disagreement

REPORTS ACCEPTED AND APPROVED

Agricultural Power Equipment Division	
Tractor Leather Driving Belts	p. 38
Axle and Wheels Division	
Brake Drums	p. 39
Passenger-Car Front-Wheel Hubs	p. 40
Felloe Bands	p. 40
Electrical Equipment Division	
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Engine Testing Forms	p. 41
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Lead-Acid Storage Batteries	p. 49
Tire and Rim Division	
Balloon Tires	Printed in this issue
Pneumatic Tires	p. 55
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Deflection and Set Test for Pneumatic Tire Rims	p. 56

had arisen as to some of the dimensions in the report which the Division feels should be cleared up before the report is accepted and approved by the Society.

Discussion on Reports

The discussions on all of the reports presented at the Standards Committee meeting are printed below.

ELECTRICAL EQUIPMENT DIVISION

Magnet Wire

The Magnet Wire Subdivision of the Electrical Equipment Division, which is comprised of Charles Marcus, chairman; John A. Harvey, C. F. Hood, H. J. Horn, L. S. Horner, D. J. Jackson, W. A. D. Peaslee, F. M. Potter and R. G. Thompson, was appointed about a year and a half ago. It has met on several occasions with representatives of the Magnet Wire Subcommittee of the Sectional Committee on Insulated Wire and Cable organized under the rules of procedure of the American Engineering Standards Committee, some time thereafter and formulated the report as submitted after reconsidering a previous Subdivision report that it was then thought would be satisfactory. The present report is substantially the same as that prepared by the Subcommittee of the Sectional Committee except that it has been amplified in some particulars. The Subdivision's report was completed at a meeting held in New York City early in January, was submitted to letter ballot by the members of the Electrical Equipment Division prior to submitting it to the Standards Committee and was approved almost unanimously by the Division, no negative votes being cast. The report, which is printed below, was originally submitted to the Standards Committee for adoption as S.A.E. Standard, but was approved for adoption as S.A.E. Recommended Practice.

Proposed Specifications for Magnet Wire

I. BARE COPPER

All bare copper wire used shall meet the requirements of the latest specifications of the American Society for Testing Materials for soft or annealed copper wire (Serial Designation B3-15).

II. ENAMEL

(1) *Uniformity.*—The wire shall be coated with a continuous insulating film of enamel of uniform thickness according to the dimensions shown in Table 1.

TABLE 1—TABLE FOR THE PERMISSIBLE ADDITIONS FOR THE ENAMELED COVERING OF MAGNET WIRE

Bare Diameter, In., Inclusive	A. W. G.	Addition, In. Minimum	Addition, In. Maximum
0.1285-0.0570	8-15	0.0015	0.0025
0.0508-0.0358	16-19	0.0012	0.0020
0.0139-0.0253	20-22	0.0010	0.0018
0.0225-0.0179	23-25	0.0009	0.0015
0.0159-0.0100	26-30	0.0007	0.0012
0.0089-0.0079	31-32	0.0006	0.0010
0.0070-0.0063	33-34	0.0005	0.0008
0.0056-0.0050	35-36	0.0004	0.0007
0.0044-0.0039	37-38	0.0003	0.0006
0.0035-0.0031	39-40	0.0002	0.0005

[1] Enameled wire that fails to meet the requirements for the addition of the enamel coating by only 0.0001 in. shall be accepted if it meets the other requirements covered in the specifications.

(2) *Quality.*—The enamel coating shall be tough and elastic, and possess a hard and smooth surface. It shall be non-hygroscopic, insoluble in mineral oils, and such as to pass all tests hereinafter mentioned. All tests shall be made on wire taken directly from the spool.

(3) *Elongation Test.*—Enamel wire having a bare wire diameter of 0.0179 in. (No. 25 A.w.g.) and smaller, shall withstand elongation to the breaking-point without the enamel rupturing or flaking so that it is perceptible to the naked eye.

(4) *Mandrel Tests for Flexibility.*—At 60 to 80 deg. fahr. (15 to 27 deg. cent.) when enamel wire is wrapped as per Table 2, the enamel shall not rupture or flake so as to be perceptible to the naked eye.

(5) *Temperature Tests.* — The flexibility of the enamel shall not be impaired by baking at 212 deg. fahr. (100 deg. cent.) for 48 hr., nor lose its original gloss or luster and the enamel shall not soften. After being allowed to cool, the enamel wire shall be capable of being wound around a mandrel as shown in Table 2, without the enamel rupturing or flaking so that it is perceptible to the naked eye.

TABLE 2—MANDREL SIZES FOR MECHANICAL TEST OF ENAMEL

Wire Size, A.w.g.	Mandrel Diameter Number of Times
8-11	5½
12-14	4
15-20	3
21-24	2

(6) *Electrical Tests.*—Dielectric tests may be conducted by either the mandrel test method or the twist test method, as outlined in the following paragraphs:

Mandrel Test.—Two layers of enameled wire shall be wound one on top of the other over a smooth mandrel of insulating material such as bakelite, hard rubber, fiber or similar material, 1 in. in diameter. The length of the winding along the mandrel shall be 1 in. and the tension applied shall not stretch or elongate the enamel wire. When alternating-current voltage at 25 to 100 cycles per second is applied between the layers the enamel shall not be punctured at less than the voltage given in Table 3. The test shall be made by applying a low voltage and raising the voltage gradually until puncture occurs. If, upon testing a sample from any spool or reel of wire, it should fail to meet this test, tests upon two additional samples shall be made. If two of the three fail, the wire shall be rejected, but if two of the three withstand the test, it shall be accepted.

TABLE 3—VOLTAGE FOR DIELECTRIC TESTS

Wire Size, A.w.g.	Voltage, A.C.
40 to 30 incl.	300
29 to 25 incl.	600
24 and larger	900

The above voltages are effective values as read on the voltmeter at breakdown.

The transformer used in making this test shall be used under the conditions set forth in the standardization rules of the American Institute of Electrical Engineers as to size and method of control to prevent wave distortion.

TABLE 4—REVOLUTIONS FOR DIELECTRIC TEST

Wire Size, A.w.g.	Revolutions per Inch
40-31	10
30-25	8
24-20	6
19-16	3
15 and larger	2

Twist Test.—Two strands of enameled wire shall be twisted together for a length of 4 in.,

the number of complete revolutions per inch corresponding to Table 4. The tension applied in twisting shall not be such as to stretch the wire, and the twist shall be uniform.

An alternating current of 120 volts shall be applied and gradually increased to the maximum voltages shown in Table 3 below which the enamel should not be punctured.

(7) *Solubility.*—Immersion in neutral mineral transformer oil for 48 hr. at 212 deg. fahr. shall not soften the enamel coating sufficiently to allow it to be rubbed off with cheese-cloth.[2]

III. SINGLE COTTON
IV. DOUBLE COTTON
V. SINGLE COTTON ENAMEL
VI. DOUBLE COTTON ENAMEL

(1) *Quality.* — The covering shall consist of unbleached cotton yarn of a suitable quality obtainable for purposes of insulation.

The wrapping of yarn shall be continuous and firmly applied. Double cotton covering shall be wrapped in opposite directions.

(2) *Amount of Covering.*—Amount of covering shall be in accordance with Tables 5 and 6.

TABLE 5—MAXIMUM PERMISSIBLE ADDITIONS FOR SINGLE COTTON-COVERED WIRE

Bare Wire Diameter, In., Inclusive	Maximum Addition, In.
0.4600 to 0.1285	0.0080
0.1144	0.0070
0.1019	0.0060
0.0907 to 0.0284	0.0050
0.0253 to 0.0056	0.0045
0.0050 to 0.0031	0.0040

The minimum permissible addition to the diameter of bare wire is 85 per cent of the specified maximum.

TABLE 6—MAXIMUM PERMISSIBLE ADDITIONS FOR DOUBLE COTTON-COVERED WIRE

Bare Wire Diameter, In., Inclusive	Maximum Addition, In.
0.4600 to 0.1819	0.0160
0.1620 to 0.1285	0.0140
0.1144	0.0120
0.1019	0.0110
0.0907 to 0.0284	0.0095
0.0253 to 0.0056	0.0085
0.0050 to 0.0031	0.0080

The minimum permissible addition to the diameter of bare wire is 85 per cent of the specified maximum.

(3) *Mechanical Test for Density.*—When the wire is bent around a radius equal to five times the diameter of the wire, the cotton wrapping shall, to the naked eye, not open sufficiently to expose the bare wire beneath.

(4) *Insulation Tests.*—Due to the hygroscopic quality of the covering herein discussed it has not been found feasible to make a recommendation covering this test.

VII. SINGLE SILK
VIII. DOUBLE SILK
IX. SINGLE SILK ENAMEL
X. DOUBLE SILK ENAMEL

(1) *Quality.*—Covering shall consist of insulating silk yarn of a quality suitable for purposes of insulation.

[2] The enamel insulation of wire wound in coils would not be injuriously affected by impregnation in insulation varnishes with benzine or petroleum-naptha vehicles or thinner, if used under proper conditions with respect to (*a*) proportion of thinner, (*b*) time of emersion and draining and (*c*) time and temperature of baking.

The wrapping of silk yarn shall be continuous and firmly applied. Double silk covering shall be wrapped in opposite directions.

(2) *Amount of Covering.*—Amount of covering shall be in accordance with Table 7.

TABLE 7—MAXIMUM PERMISSIBLE ADDITIONS FOR SINGLE AND DOUBLE SILK-COVERED WIRE

Bare Wire Diameter, In., Inclusive	Maximum Addition, In., Single Covered	Maximum Addition, In., Double Covered
0.0570 to 0.0031	0.0020	0.0040

The minimum permissible addition to the diameter of bare wire is 75 per cent of the specified maximum.

(3) *Mechanical Test for Density.*—When the wire is bent around a radius equal to five times the diameter of the wire, the silk wrapping shall be to the naked eye not open sufficiently to expose the bare wire beneath.

(4) *Insulation Tests.*—Due to hygroscopic quality of the covering herein discussed it has not been found feasible to make a recommendation covering insulation tests.

XI. PACKING FOR ALL WIRES

(1) *Spool or Reel Dimensions.*—All wire is to be packed on standard spools as per Table 8.

TABLE 8—SPOOL DIMENSIONS

Wire Size, A.w.g.	Maximum Diameter of Head, In.	Maximum Length of Spool Overall, In.	Minimum Diameter of Arbor, In.
8-20	24	12	1¼
10-20	18	12	1¼
12-20	12	8½	1¼
14-20	9	8½	1¼
20-26	6	4¼	⅝
25-33	4½	4	⅝
25-37	4	4	⅝
34-40	3	4	⅝
38-44	2½	4	⅝

(2) *Continuity of Winding.*—The wire shall be in one continuous length in each package. Such joints as may be necessary to bring the wire up to the minimum weight called for in Table 13 shall be made by brazing in a good workmanlike manner so that the diameter of the wire after brazing is substantially the same as in the other portion of the wire, and the joint must be so smoothed-down that there will be no rough places to cut the insulation. The wire at a joint must be substantially identical in softness and dimensions with the rest of the wire and have at least 95 per cent of its strength.

(3) *Density of Winding.*—The wire shall be wound on spools under such a tension as will give an even and compact winding. A soft body of wire on the spool will not be satisfactory. On 0.0201 in. (No. 24 A.w.g.) and finer the inner end of the wire on a spool must be brought out so that it will be available.

THE DISCUSSION

F. C. KROEGER:—I feel that the report as outlined is of value but I would like to move that it be accepted as S.A.E. Recommended Practice rather than as S.A.E. Standard.

F. W. ANDREW:—Some new developments are being made in the cotton covering that are along good engineering lines. Before I came here I thought it ought to be accepted as we had it but now I think it should be changed for adopting as S.A.E. Recommended Practice.

PARTS AND FITTINGS DIVISION REPORT

FUEL AND LUBRICATION TUBE FITTINGS

THE DISCUSSION

WALTER C. KEYS:—Yesterday it was suggested that the fuel and lubrication pipe fittings now printed on pp. C46 and C47 of the S.A.E. HANDBOOK as S.A.E. Recommended Practices should be approved by the Division, the Standards Committee and the Society as S.A.E. Standards. The members of the Division voted as favoring the change of status of these standards, with a slight change in the name. Instead of calling them "fuel and lubrication pipe fittings," we thought they should be "fuel and lubrication tube fittings" because brass and copper tubing is always called tubing and not pipe. I therefore move that the Standards Committee approve changing the status of the specifications on pp. C46 and C47 of the S.A.E. HANDBOOK to S.A.E. Standards.

A. BOOR:—I notice that some of the thread pitches that are specified in the report that was withdrawn do not correspond with the thread pitches as given in the National Screw Threads Commission or the Sectional Committee reports.

MR. KEYS:—These tube fitting threads were adopted long before I had anything to do with this Division. Mr. Burnett said yesterday that gradually all of the S.A.E. Standards and Recommended Practices specifying threads will be revised to conform with the new screw-thread specifications.

I will say that the manufacturers of these fittings were pretty generally represented at the meeting yesterday and at our other meetings, and that the pitches given in these specifications are satisfactory to them and are being used.

E. H. EHRMAN:—Twenty-four threads per inch likewise 37 threads have been used for these diameters for various purposes for a great many years and to change them at this time would make endless annoyance and expense. Similarly, as an illustation, the 7/8-in. spark-plug thread is not a National Screw Thread Commission standard pitch. Many special threads will be used for special purposes for a long time to come. The Society long ago established a fine-thread standard and it may be slightly modified in the future. Other conditions change, and we have to meet the changing conditions as well as established practice, so no hard or fast rules with regard to pitches can be made any more than with regard to the use of unilateral or bilateral dimensions. Individual cases or applications dictate more strongly sometimes what should be than do so-called fundamental principles.

KARL L. HERRMANN:—Some years ago we took up the matter of pipe fittings with a number of motor-car builders and found a great many of them using the S.A.E. Standard in this connection. We have since been working to that end and if this proposal is changed it would mean no end of trouble because the first thing we will hear is "This is not the standard; we have something else now, and it is hard to get this into production."

It seems to me, as Mr. Ehrman pointed out, that this is a rather bad time to begin to standardize on things other than our own standard. It is just seemingly setting-up the standard and then going around and knocking it down wherever you get the chance to.

MR. EHRMAN:—Let me say that these pitches were in use long before the Society undertook to standardize them and they are practically standard on the market today. I have made collections of samples of different types of compression fittings and of solderless types from various sources. I found that almost invariably the threads run 24 per inch up to the largest size.

Another thing to be considered probably has more to do with retaining these pitches than anything else. If the pitches are increased it will increase the diameter of the outside shell and of the inside part because the threads will be deeper. It will increase the cost of the metal and work against the purchasing department of the automobile companies.

If fittings with a coarser thread were offered, they would take the finer thread, because they would find it would be cheaper. That has already happened on the ball-joint with one of the largest automobile companies. This part was standardized by the Society some time ago, but now they are buying a special part about 3/16 in. shorter because it saves a little bit of steel.

C. M. MANLY:—I think there is a point of misunderstanding here in reference to what the Screw-Threads Division's report covers. The Screw-Threads Division is not supposed to consider threads of all kinds applied to all objects. It is interested only in the matter of threads for bolts, nuts and devices for fastening members together in the sense of pulling them together. The report is not intended to specify the only screw threads that are used on particular diameters of bolts and nuts. Neither is it necessarily intended for all of these various applications any more than to a radiator or a tank cap or anything of that kind. I think that is one thing which must be kept in mind all the time. If the National Screw Thread Commission's Report had not been confined to the devices that it has, we would still be discussing it, and it would never have reached its present stage of acceptance.

MR. BOOR:—Another point in connection with the fine thread is the ease with which the nut can be put on and cross the thread, which does not happen if a coarser thread is used.

CHAIRMAN E. A. JOHNSTON:—The motion before us is only to change the present recommended practice to a standard and to call the fittings "tube fittings" instead of "pipe fittings."

[Mr. Keys' motion was seconded and carried with no negative votes.]

SCREW-THREADS DIVISION REPORT

DIMENSIONAL TOLERANCES

THE DISCUSSION

EARLE BUCKINGHAM:—With regard to dimensional tolerances we are very anxious that not only the material in our S.A.E. Standards shall be of the best, but that the form in which they are presented shall represent the best practice that we know of. As a first step toward that, this report on the methods of designating dimensional tolerances has been prepared so as to have available some guide toward uniform practice by all of the Divisions of the Standards Committee in arranging their reports but having nothing to do with the subject matter of them. Each Division must decide for itself what should go into the standard, but when that is decided, they certainly should try to have as nearly uniform a method as possible of specifying tolerances.

SCREW THREADS

[Tables 10 and 11 on pp. 52 and 53 of the January issue of THE JOURNAL covering the close fit for screws and nuts in the coarse-thread series were included in the report through error. These tables will be replaced in the

report when published in data sheet form by tables covering the free fit for screws and nuts in the fine-thread series.]

TIRE AND RIM DIVISION REPORT

Balloon Tires

At a meeting of the Tire and Rim Division in Cleveland last September the development of balloon tires and their rims was discussed, as it was expected several companies would soon announce production on such tires. Due to differences of opinion that were known to exist among the tire and rim companies regarding the dimensions of these tires and rims, and the Division's belief that a suitable standardization program could be set up to guide the practice of tire and rim manufacturers and car builders, it was decided to suggest to the Rubber Association of America that a general conference be called of representatives of the Rubber Association, the National Automobile Chamber of Commerce and the Society for the purpose of reaching a decision by all parties interested on a program that would save the industries considerable time and expense. Chairman Vincent of the Division accordingly wrote the Rubber Association, in reply to which that Association indicated that a difference of opinion regarding balloon tire and rim dimensions did exist, that individual tire companies had been conferring with car builders regarding their views on balloon tire development and that the Association hoped plans could quickly be crystallized from these investigations to permit of conferring with other branches of the automotive industry. Early in December the Society received definite information in the form of a general bulletin issued by the Rubber Association giving a recommendation of the executive committee of the Tire Division of the Rubber Association as concurred in by the Tire and Rim Association of America. This bulletin was sent to the Society for its consideration and approval. A meeting of the Tire and Rim Division was held with engineering and executive representatives of car builders in New York City on Jan. 9, those present being J. G. Vincent, chairman, and B. B. Bachman, H. M. Crane and A. J. Scaife, members of the Division. Others in attendance were: George Allen, Dodge Bros.; C. L. Sheppy and O. M. Burkhardt, Pierce-Arrow Motor Car Co.; L. A. Chaminade, Studebaker Corporation of America; D. G. Roos, Locomobile Co. of America; Howard Marmon, Nordyke & Marmon Co., A. J. Baker and C. L. White, Willys-Overland Co.; F. E. Watts, Hupp Motor Car Co.; T. J. Lítle, Jr., Lincoln Motor Car Co.; Fred Zeder, O. R. Skelton and Carl Breer, Chrysler Motors Corporation; C. B. Whittelsey, treasurer of the Society and president of the Hartford Rubber Works; H. S. Firestone, president, Firestone Tire & Rubber Co.; J. G. Swain, vice-president, Firestone Steel Products Co.; C. F. Clarkson, general manager of the Society of Automotive Engineers and R. S. Burnett, manager of the Standards Department of the Society of Automotive Engineers.

It was felt that at best the problems of balloon tires and their rims and wheel diameters are still in the development stage and that any specifications that might be approved at this time may require modification but that it is desirable to have available some definite recommendation that will afford a suitable list of balloon tire and rim sizes for passenger cars. It was voted that the recommendation submitted by the Rubber Association for the cross-sectional diameters, rim diameters and rim widths for balloon tires be endorsed by the Society and published in the S.A.E. Handbook as General Information with an explanatory paragraph indicating that the Society approves the recommendation of the executive committee of the Tire Division of the Rubber Association as such, but that the Society should not at this time give it the full official weight of its endorsement as an S.A.E. Standard or Recommended Practice. The Tire and Rim Division therefore submitted the following report to the Standards Committee:

Table of Balloon Tire and Rim Dimensions

The Tire and Rim Division recognizes the necessity for a definite list of balloon-tire cross-sectional diameters and corresponding rim diameters and widths that it is believed will meet the requirements of present and early future applications until such a time as the further development and use of this type of tire and rim warrant the adoption and publication by the Society of a definite standard. The following recommendation of the executive committee of the Tire Division of the Rubber Association of America as printed in Bulletin No. 274 of that organization dated Nov. 18, 1923, which was concurred in by the Tire and Rim Association of America, should be printed in the S. A. E. Handbook as General Information, with the recommendation that automobile builders using balloon tires and rims select sizes from this list so far as possible.

Cross-Sectional Diameter, In.	Rim Diameter, In.	Rim Width, In.
4.40	21	3½
5.25	21	4
6.20	21	4½
6.20	20	4½
7.30	20	5

THE DISCUSSION

J. G. Vincent:—There has been considerable agitation and discussion of the subject of balloon tires. A short time ago the Division was sent a report from the Rubber Association of America in which we were given the particulars pertaining to the standards that have been adopted by that organization for balloon tires as to the cross-sectional area of tires and rim widths and diameters.

At our meeting in New York City a short time ago, we invited a number of the motor-car engineers simply to have a more or less informal discussion of these standards and to try to bring out some information toward crystallizing our ideas as to the probable value of these standards and the probable objections to them. After considerable discussion we felt that at this time we could not do better than to approve the list for publication as General Information as being the Rubber Association standard. We are not adopting it as S.A.E. Standard, but only to publish it as the Tire and Rim and Rubber Association's standard which is approved by the Society.

I would like to say, however, that it was the sense of our informal meeting in New York City that we automotive engineers want to get closer together with the representatives of the rubber and rim interests. I emphasized this insistently to get those present to pass this standard in view of objections to it by some people. The situation will work a hardship on somebody regardless of how we go, but certainly we ought to be able to proceed with this balloon tire standardization in a little more orderly manner than we have been able to do with the work on regular pneumatic tires. If we do not, after another year it will be too late to accomplish anything.

PNEUMATIC TIRES

THE DISCUSSION

MR. VINCENT:—This report is practically the same as the one which we made some time ago but which was held up then because certain interests thought that developments were under way which might lead us to change our recommendations. But as time has gone on, it does not seem that those changes have materialized, and in the light of the present situation when so much interest is centering around another type of tire, very many of us have seriously doubted whether this practice would be apt to be generally changed, except that certain sizes may go out of use.

At the meeting of the Tire and Rim Division in Cleveland last September we went over the matter pretty carefully. A few suggestions have been made since then but the sizes as listed in this report on the proposed revision of the S.A.E. Standard for Pneumatic Tires represent, so far as I know, the consensus of opinion. It is thought by some that certain of the sizes in the list should be dropped, and maybe they should be, but that is largely for you to discuss.

J. E. HALE:—It seems to me that the 30 x 3½-in. straight-side tire should be included as it is the Chevrolet size that is used right along.

W. W. DAVISON:—It seems to me that the 30 x 3½-in. size should be included. As makers of wire wheels, we furnish 30 x 3½-in. straight-side rims for the same size tires for other cars than the Chevrolet, for instance, Gray.

CHAIRMAN JOHNSTON:—As there seems to be no further discussion, would someone like to offer an amendment to Mr. Vincent's motion, to include the 30 x 3½-in. straight-side tire?

MR. HALE:—I should like to offer an amendment that the 30 x 3½-in. straight-side tire be included in this list.

[The report on passenger-car tire sizes was approved with the 30 x 3½-in. straight-side tire included in the list for the 30 x 3½-in. rim.]

HAROLD W. SLAUSON:—I think Mr. Hale started to bring up the question as to why the truck tires for the 20-in. rim diameter were not included in the table. That is standard practice now with the Rubber Association and the Tire and Rim Association, although I do not know the actual standards passed by those organizations.

MR. VINCENT:—That did not come up for discussion at our meetings, but it is possible that we should add those sizes either now or later. I think, however, it would be better to let it go over for consideration at a later meeting.

MR. HALE:—I would like to add that this move to popularize the 20-in. rim-diameter did not get much support, I think because the brake-drums of the motor trucks are so large that it could not be worked out very well. It was claimed that the smaller-diameter tires brought the body of the truck lower to the ground and all that sort of thing.

Motorbuses are being used so much more that we might say the resistance to using these tires is being overcome by the axle manufacturers working out different brake-drum diameters and so forth. It appears to the tire manufacturers that the use of the 20-in. diameter truck-rim will increase very rapidly from now on and I think we feel that it will not be long before very few new trucks will be built with the larger diameters.

MR. VINCENT:—I think that should be worked out, but it is a question whether we should try to do it here hurriedly or whether we should approve this report that represents present practice.

A. J. SCAIFE:—The question in my mind is whether the 20-in. or the 22-in. rim is right for motor trucks on account of it making the vehicle possibly too low. Other things besides interference with the brakes are to be considered in reference to their use on trucks. I think that motorbuses will develop to be as different from motor trucks as passenger cars are from motor trucks.

C. B. WHITTELSEY:—Can we not put this rim size into the list subject to the specifications as adopted by the Tire and Rim and the Rubber Associations, which would save the delay in adopting them?

C. F. CLARKSON:—I think that could be done if it is the sense of this committee.

MR. VINCENT:—An amendment would be in order to add the 20-in. base diameter and tire sizes subject to a check by the Division.

[The report was approved with the addition of the 20-in. diameter tires and rims subject to check by the Division.]

CATALYSIS IN INTERNAL-COMBUSTION ENGINES

IN connection with the remarks made by Dr. Herman Schlesinger[1] in discussing the paper presented at a meeting of the Mid-West Section by Prof. H. B. Lemon, entitled The Nature of Matter, and published in the December, 1923, issue of THE JOURNAL, Edward Sokal, vice-president of the Katalite Corporation, New York City, has called attention to the series of experimental investigations of the influence of solid catalytic agents on combustion in the internal-combustion engine that he has undertaken in the last 3 years. These agents were used in various ways but chiefly as a thin refractory coating applied to the surface of the cylinder-heads. At first an investigation was made at the University of Michigan, with the cooperation of Prof. E. H. Leslie, to determine quantitatively the effect of such catalytic agents on the oxidation of the hydrocarbons, such as gasoline and kerosene, that are now being used in internal-combustion engines. The next step was to test the actual effect of such catalytic coatings on the performance of internal-combustion engines under conditions of practical use. These experiments and investigations, which have now extended over a number of years and have embraced several hundreds of tests, have confirmed fully, Mr. Sokal states, the opinion expressed by Dr. Schlesinger that catalysis is a matter of extraordinary importance in the problem of the internal-combustion engine. It has been found, he says, that by the use of adequate catalytic coatings combustion in internal-combustion engines is both accelerated and rendered more complete, with the obvious results of greater power output and better fuel-economy.

[1] See THE JOURNAL, December, 1923, p. 471.

Process of and Equipment for Fender and Body Enameling

By GORDON LEFEBVRE[1]

ANNUAL MEETING PAPER *Illustrated with* DRAWINGS AND PHOTOGRAPHS

RECENT improvements in the mechanical equipment and the processes employed in the various car-assembling plants of a large motor-car building company are described, as a result of which these departments have been transformed from the most unsightly parts of the factory building into the cleanest, most comfortable and least dangerous. The processes to which special attention is devoted are those for the enameling of fenders and sheet-metal parts and such small parts as various stampings, forgings and malleables and cover the application of two coats of an asphaltic-base enamel and a subsequent baking at about 450 deg. fahr.; in body enameling they cover the application of three coats of similar material and baking at from 290 to 350 deg. fahr.

The course of the various parts is followed from the time of their receipt to that of their delivery to the assembling department to which they belong. When first received from the stamping department or from outside sources they are carefully inspected. They are protected from rust at the source with an outside coating that may be easily removed later by a washing process that precedes enameling. Successive improvements in the fender-enameling ovens consisted of replacing the original box-type ovens, which were open at one end and in which the dipping was done by hand, with those of the semi-continuous type, open at both ends and arranged in line in such a manner that certain parts could be dipped and hung on the conveyor bars while other parts previously dipped and run into the ovens were baking; these ovens in turn were superseded by those of the continuous type in which the parts are hung on the conveyors at one end, are automatically dipped, allowed to drip and baked and not handled again until they finally emerge at the discharge end completely finished with a double coating of enamel. The body-enameling ovens likewise were changed from the original square-box type with doors in the front to the tunnel-type equipped with power conveyors. The last three batteries built by the company were further improved by being suspended overhead with the ends inclined to the floor, thereby forming a seal at each end and completely trapping the oven.

The ideal oven-wall should have low thermal-conductivity, low thermal-capacity and the minimum amount of through metal, should contain the minimum amount of metallic materials, form a rugged construction, be designed, if possible, to allow the ready removal of the oven without waste of material, provide a smooth inner surface to facilitate cleaning, be completely dust-tight and non-dusting and have a reasonably low first cost of construction. The ideal conveyor should carry the body through all three coats without the necessity for removing it from the conveyor after each bake and mounting it again to flow-on the succeeding coat; but with large production this would require an unreasonably long building.

A system of handling enamel is described that ensures absolute cleanliness and safety, prevents waste and provides centralized and economical operation.

Indirect gas heaters were superseded by electric heaters so that electric heating became standard throughout, with the exception of one bank of body ovens in which electric heaters were used in the central zone to supplement high-pressure steam-coils. Electric heating was satisfactory so far as ease of operation and accuracy of control was concerned, but was found to be costly and the cause of numerous fires in the ovens. As a result the electric heaters have been discarded in favor of indirect oil-fired hot-air heaters, each oven having its own individual heater of the multiple-unit type. Compared with electric heaters, the first cost of the equipment is favorable, the cost of maintenance is negligible, the labor operation cost about the same and the fuel cost per unit much less.

In addition to arrangements for automatically emptying the tanks in case of fire, the dip-tanks and drainboards are protected with automatic Foamite extinguisher heads and the fender ovens are equipped with open-end high-pressure steam lines for smothering the fire with steam. Body-oven flow-rooms are protected by water-sprinkler heads.

Special attention is devoted to cleanliness, not only of the materials but of the equipment, tanks, conveyors, floors and the like. A ventilation system injects washed air into the rooms, which creates a static pressure and a flow of air current outward through the doors and the windows. This prevents dust-laden air from entering.

Distribution of the finished enameled parts to the various assembling departments is done by overhead conveyors that reduce the labor cost of handling, minimize the rejections on account of injury, occupy less floor space and at the same time provide means of carrying a small stock of finished parts ahead of the assembling operations.

THE process of enameling or japanning fenders, sheet-metal parts and bodies and the equipment involved have been the subjects of intensive study in recent years by most motor-car builders whose product reaches quantity production. The result has been a radical improvement in the equipment and a consequent simplification of the processes. The attendant benefits are a decided improvement in the quality of the product and a marked decrease in the cost of labor, material and fuel. Until very recent years the fender and body-enameling departments in the assembly plants of the larger car companies have been the most unsightly parts of the factory building, places to be avoided when possible, the floors covered with slippery enamel, the rooms reeking with choking fumes and smoke and the whole in constant danger of fire or explosion. These conditions have been so improved in some of the plants that it is no exaggeration to state that these departments are now the cleanest, the most comfortable and the least dangerous parts of the plant.

This discussion is not intended as a technical exposition of the art of enameling but as a simple recitation

[1] Chevrolet Motor Co., Detroit.

of the improvements wrought in the mechanical equipment and the processes employed in the various car-assembling plants of the company with which I am associated. This company, in conjunction with others in the General Motors Corporation, has spent a vast amount of money in development. It is not felt that the millennium in enameling has been attained or even that the present methods are satisfactory. It is believed, however, that a great improvement has been accomplished and that a summarized history of the various stages of development, together with a recitation of the difficulties met with and overcome and the obstacles yet to be surmounted, will prove of interest and benefit to the trade.

It should be understood that, for the purposes of this discussion, the enameling of fenders and sheet-metal parts and also of small parts, such as various stampings, forgings and malleables, is intended to cover the applica-

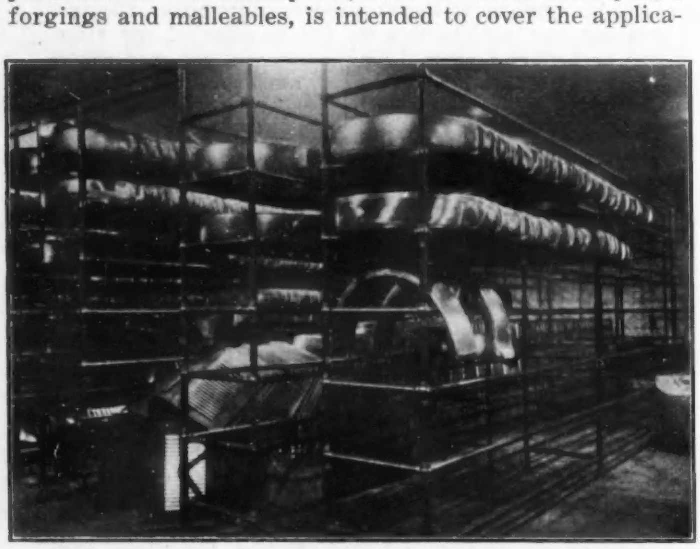

FIG. 1—PIPE RACKS USED FOR THE STORAGE OF FENDERS AND SHEET-METAL PARTS

The Present Arrangement of Using Racks Built Up of Standard Pipe and Pipe Fittings Is the Outcome of Experiments with Other Schemes That Were More or Less Unsatisfactory. Parts of Various Sizes Can Be Accommodated and the Storage Space Can Be Extended to the Ceiling if Desired. The System Possesses the Advantages of Cheapness and Durability and Permits a Large Quantity of Stock To Be Stored in a Restricted Floor-Area

tion of two coats of an asphaltic-base enamel and a subsequent baking at about 450 deg. fahr. With reference to body enameling, it is understood to cover the application of three coats of a similar material and a bake at about 290 to 350 deg. fahr. With reference to our particular product, a set of sheet metal for a complete automobile includes 11 pieces and weighs 105.3 lb.; a set of small parts includes 14 pieces and weighs 45.4 lb.; a phaeton body, ready for enameling, contains 121 lb. of wood and 125 lb. of metal.

INSPECTION OF RAW STAMPINGS

Raw stampings of sheet-metal parts and body panels are received from the manufacturing division or the outside source of supply in bulk. A portion of each shipment is checked over a fixture to insure that the proper forms and dimensions are being adhered to. Each part is carefully inspected as to surface; all parts are eliminated that show pits, stretcher strains, waves and other objectionable defects. The sheet metal specified for fender stock is full-pickled, full cold-rolled and reannealed sheet steel, fender and hood grade. The grade specified for fender crowns is cold-rolled strip steel and that for body steel is full-pickled, full cold-rolled and reannealed sheet-steel automobile-body stock. Because of the fact that fender parts are covered with only two coats of enamel and the body panels with only three, it is absolutely essential that the sheet stock be of the best grade as specified, so as to avoid the appearance of such defects that may not be covered by the comparatively thin coatings. It has been found that the application of two or three coats as outlined above will exaggerate the defects rather than hide them.

It is believed that beneficial results would accrue to motor-car builders through an educational campaign for the purpose of familiarizing sheet mills with modern processes of enameling and the requirements and limitations to which motor-car builders are held by the expectations of the buying public.

An essential item in handling and storing raw stampings is the protection of the stock against rusting. It is believed that the protective coating in each individual case should be worked out in a manner that will be best suited to the subsequent removal of the coating in the preliminary washing operation. We require our stamping departments and outside stamping sources to use a coating that is readily removable in our particular style of washing machine and readily soluble in our washing compound.

LOCATION OF EQUIPMENT AND STOCK STORAGE

Both the fender and the body-enameling equipments are located in such a manner as to fit in best with a progressive method of assembling. The loading ends of the fender ovens are located on the first floor of multi-story buildings to avoid elevating the bulky parts. In all types of building these loading ends are near receiving docks to minimize the trucking of parts to storage. The discharge or finish ends of these fender ovens are located nearest the point on the main assembly lines where the bulk of the material is used. Enameled parts that are not used near these points are conveyed from the finish end to the point where they are used, as will be explained later.

The body ovens are located with the same idea in mind. The flowing end of the first-coat ovens is located adjacent to the finish end of the body-assembling department, while the finishing end of the third or last-coat oven is next to the receiving end of the trim department.

It may be said here that no attempt is made to carry a reservoir or a surplus of finished sheet-metal or finished bodies between operations. The enameling operations are scheduled to synchronize with the main assemblies and a continuous flow of enameled parts is maintained to the production lines. Such a method obviates the necessity for a large storage space for finished parts and reduces the rejections that result from rehandling. It does, however, require a very careful and thorough scheduling of raw materials to the enameling operations to assure continuous production. This method of operating has been found to present a very fertile field for improvements.

The storage of raw stampings is a problem in itself. Each part must be considered in the light of its own particular requirements, its adaptability to nesting, its susceptibility to crushing or distortion, its weight and its size. We have tried several schemes with varying degrees of success, and at present are using racks built up of standard pipe and fittings of the type shown in Fig. 1. The tiers are designed to accommodate parts of various sizes, and if desirable the storage may be carried to the ceiling. This storage system possesses

the merit of cheapness and durability and allows a large amount of stock to be stored in a restricted floor-area.

Preparation of Metal for Enameling

The first method used for the cleaning of fenders and sheet-metal parts preliminary to enameling was to dip these parts by hand into a large vat of gasoline to remove the protective coating of grease. The seams were blown out with compressed air to ensure the removal of all liquids, and the parts were thoroughly wiped by hand with dry rags. They were then wiped off with a tacky rag and carried to the dip-tank.

This method was laborious and was soon discarded. Automatic washing-machines were introduced in which the washing was accomplished by flooding the parts with hot water containing a solution of various washing compounds and by subsequently rinsing them in

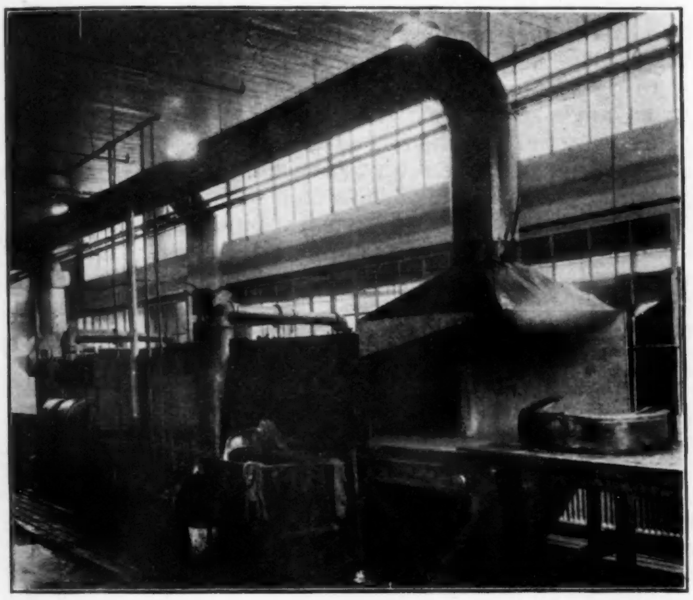

Fig. 2—Fender Washing Machine and Drying Oven
In This Combination the Metal Parts Pass Through the Washing Machine and Are Discharged by the Washing Machine Conveyor upon Another Conveyor That Carries the Cleaned Wet Parts through a Gas-Heated Oven and Discharges Them on a Table at the Loading End of the Fender Enameling Conveyor

clean hot water. The parts passed through the long tunnel-type washing-machine on a slatted conveyor, moving first through the flood of cleansing water and then through the rinse. The drying, seam-blowing and tack-ragging were done by hand in the same manner as in the old gasoline washing method.

To get away from the use of liquids in washing and the subsequent costly hand-drying, experiments were conducted with a view to removing the grease coatings by heat. No perfectly satisfactory method has been evolved for doing so, but it is believed that this can be accomplished. It is certainly well worth the time and the effort, as the labor cost of cleaning and drying preliminary to enameling is, in many cases that have come under my observation, greater than the labor cost of the actual enameling operations. These experiments consisted essentially of passing the metal parts through an oven preliminary to dipping, the temperature of the oven varying from 400 to 750 deg. fahr. When the proper heat was attained, it was found that the grease was deposited on the metal in a powdered form. The difficulty came in removing this powder economically, particularly that which accumulated in the seams. We are still working on this process.

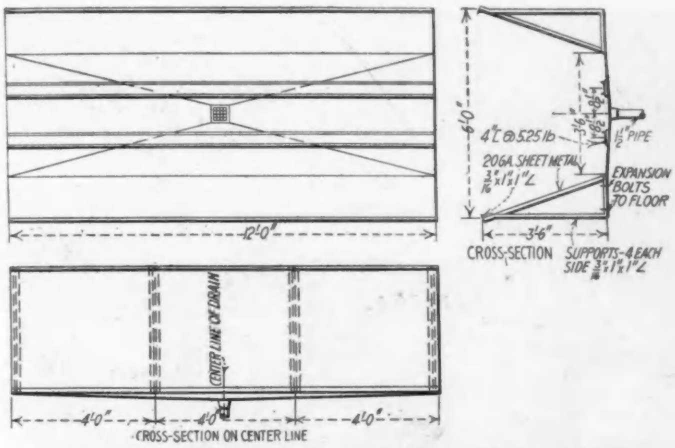

Fig. 3—Stand Used for Washing Bodies with Gasoline
The Bodies Are Trucked over the Drain and Are Washed by a Brush and a Liberal Application of Gasoline That Is Recovered from the Drain, Distilled and Used Again

At present we are running all the sheet-metal parts through a washing-machine as outlined above. The washing-machine conveyor discharges the pieces on to another conveyor that carries the cleaned wet parts through a gas-heated oven and discharges them on a table at the loading end of the fender-enameling conveyor. This drying-oven is heated to 400 deg. fahr. and is of such a length that all parts are thoroughly dried before emerging. This, of course, eliminates all the former seam-blowing and hand wiping, and the parts are ready for tack-ragging and dipping. Fig. 2 shows one of the washing machines now in use and the drying oven at the end.

The cleaning of bodies is a comparatively simple proposition. The bodies are assembled without first removing the grease. Until recently each body was trucked over a suitable drain and washed by a brush and a liberal application of gasoline. The fixture in which this washing was done is illustrated in Fig. 3. This gasoline was recovered from the drain, distilled and reused. At present, however, the bodies are taken directly from the body-building department, placed on the first-coat oven conveyor and washed just before flowing with high-test gasoline and a rag. Only enough gasoline is used to remove the grease. There is no excess or wastage on the floor.

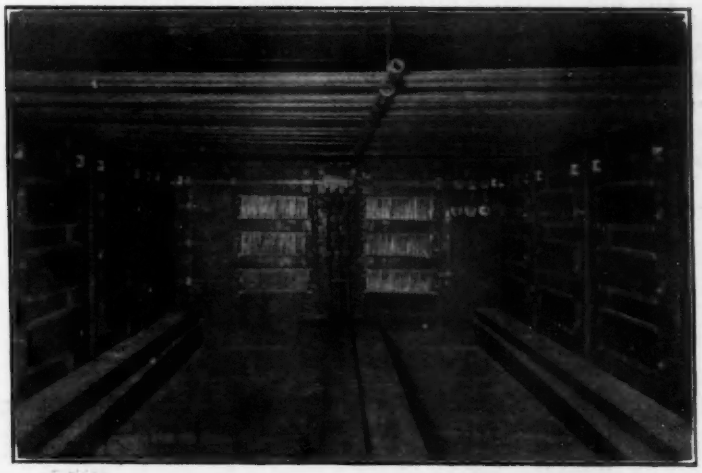

Fig. 4—Interior of the Box-Type Fender Oven
This Oven Is Typical of Those First Used for Drying Fenders and Small Parts at the Chevrolet Plant. A Door Was Provided at One End for the Introduction and Removal of the Parts Which Were Hung from the Pipe Bars Suspended from the Ceiling. Electricity Supplied the Heat Required

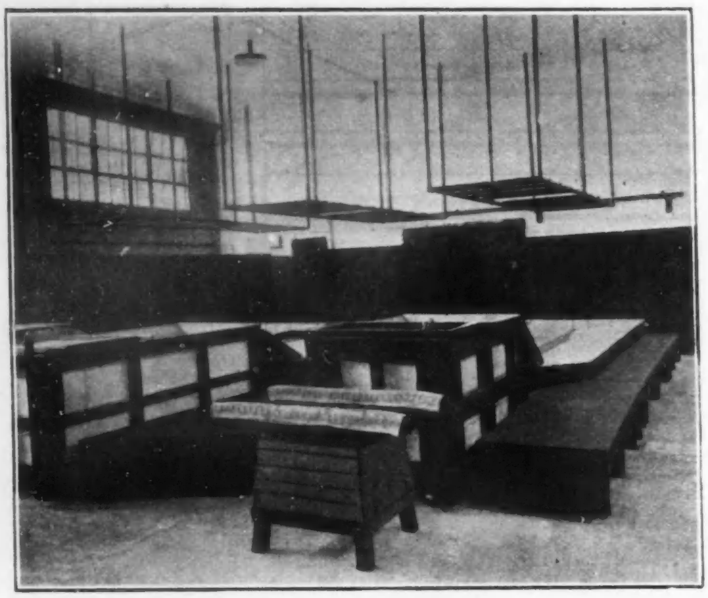

FIG. 5—DIP-TANKS AND DRAIN-BOARDS FOR DIP ENAMELING
The Parts To Be Finished Were Dipped by Hand into Stationary Tanks of Enamel and Were Hung on the Overhead Pipe Bars To Drip before Being Placed in the Oven To Bake the Enamel

TYPES OF FENDER-ENAMELING OVEN

The first fender and small parts ovens used at our plant were of the box type with doors in one end and pipe bars along the ceiling for hanging the pieces as illustrated in Fig. 4. These ovens were heated either with indirect gas-heaters or with electric heat. They were ventilated by drawing air from the two sides and the center through the ducts at the bottom of the oven. Fresh air was admitted through two upper ducts along the sides.

The parts were dipped by hand into stationary tanks of enamel, as shown in Fig. 5, and were hung to drip on pipe bars overhead before being placed in the ovens to bake. The labor and the fuel cost to operate this type of oven was very high, as all the pieces were handled by hand in putting them into and taking them out of the ovens, and the heat losses were great owing to the fact that the doors were opened and the oven cooled down to approximately room temperature between bakes.

The next advance in fender-enameling equipment was the so-called semi-continuous type of oven shown in Fig. 6. The first and second-coat ovens were of the same design, having double-paneled walls, and doors on both ends. They were located in a straight line about 65 ft. apart. A double-strand conveyor with pipe cross-bars was carried through both ovens at the ceiling. Ahead of each oven and underneath the conveyor was located a dip-tank and a drip-pan similar to those used with box-type equipment. These ovens were heated and ventilated in the same manner as the box-type.

The advantage of this type of equipment lay in the fact that parts could be dipped and hung on the conveyor bars while the parts previously dipped and run into the ovens were baking. This resulted in a saving of time and heat, as the ovens could be loaded and unloaded with much greater rapidity than those of the box type. Nevertheless, it was felt that the labor and the fuel costs were higher than they should be, and work was begun on a design of open oven with trapped ends that would allow a continuous passing of parts and at the same time conserve heat.

Three batteries of this new continuous type of fender-enameling equipment were built simultaneously at three different assembling plants. Each battery consisted of two ovens, one for the first coat and one for the second, the arrangement being as indicated in Fig. 7. The ovens were open at each end and the ends inclined downward at an angle of 45 deg. The horizontal portions of the ovens were built on the second floor and the inclined ends extended through the second-floor slab into the first floor a sufficient distance to form a trap within the oven.

A double-strand conveyor with pipe cross-bars was used for carrying the parts through the ovens. The conveyor automatically dipped the parts into a large dip-tank of enamel ahead of each oven. A conveyor of sufficient length was provided to ensure the proper dripping of parts before they entered the oven. This type of oven effected a great saving in labor, material and fuel. The raw parts were hung on the conveyor at one end and were not handled again until they finally emerged at the discharge end completely finished. The percentage of rejections was greatly decreased by eliminating the hand dipping and handling. The ovens were kept at a continuously uniform temperature and no heat was dissipated by the alternate heating and cooling between bakes.

All the later types of oven have been modifications of these. On three recent installations shown in Figs. 8 and 9 the ovens have been built on the roof with a protective penthouse and the inclined ends extended through to the first floor. This greatly increases the length of the inclined legs and more positively traps the heat. It allows the battery to be placed in a shorter overall length of floor space and insures a baking curve of almost ideal characteristics. The parts are gradually brought from room-temperature to maximum baking-heat, are held at that point for the requisite time and are then reduced in temperature gradually without any mechanical effort.

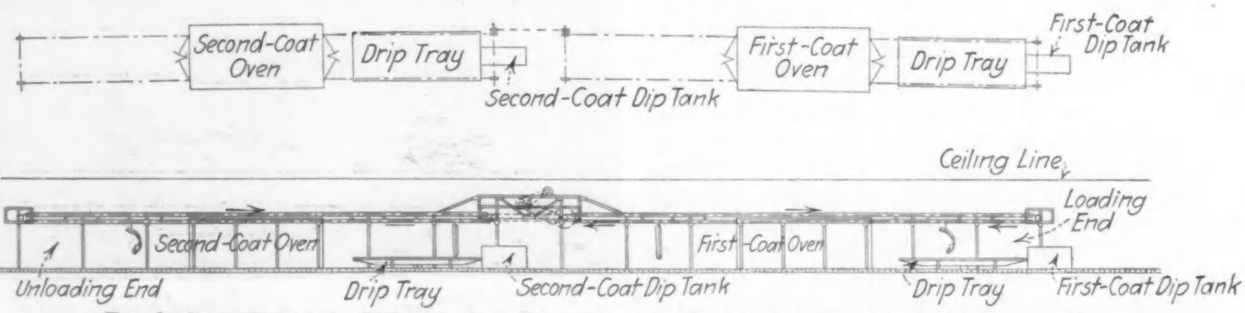

FIG. 6—PLAN VIEW AND SECTIONAL SIDE ELEVATION OF A SEMI-CONTINUOUS TYPE OF FENDER OVEN
This Oven Was the First of the Modern Equipment Now Used. The First and Second-Coat Ovens, Which Were of the Same Design with Double Panelled Walls and Doors at Both Ends, Were Located in a Straight Line about 65 Ft. Apart and a Double-Strand Conveyor at the Ceiling with Pipe Cross Bars Carried the Work through Both Ovens. The Dip-Tank and the Drip-Tray at the Left of Each Oven Were Similar to Those Used with the Box-Type Oven Illustrated in Fig. 5 and the Heating and Ventilating Arrangements Were the Same in Both Types.

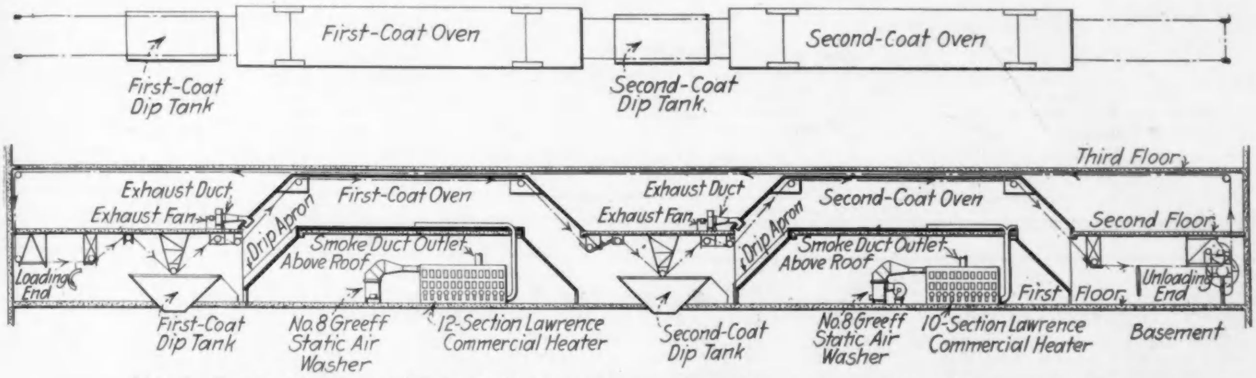

FIG. 7—FIRST CONTINUOUS-CONVEYOR TYPE OF FENDER OVENS INSTALLED AT THE CHEVROLET PLANT
This Oven Is an Improvement on That Illustrated in Fig. 6 Since It Permits a Continuous Passage of the Parts and at the Same Time Conserves Heat. The First and Second-Coat Ovens Are Open at Each End and the Ends Incline Downward at an Angle of 45 Deg. The Loading and Unloading Stations and the Dip-Tanks Are Located on the First Floor and the Horizontal Portion of the Ovens Is Built on the Second Floor

TYPES OF BODY-ENAMELING OVEN

The first body-enameling ovens used by Chevrolet were of the square-box type with doors in the front. The bodies were flowed on trucks over stationary flow-pans and were trucked into the oven for baking. These ovens held eight bodies and were ventilated and heated in the same manner as the box-type fender-ovens, either gas or electricity being used. The objection to this type of oven was the same as that to the fender ovens, namely, an excessive labor-cost in handling the bodies in and out of the oven and the excessive loss of heat through heating and cooling the ovens between bakes. Furthermore, these ovens with the necessary flow-pans required a large amount of floor space. In the older Chevrolet assembling plants, the body-enameling departments occupied approximately one-third the total factory floor-area.

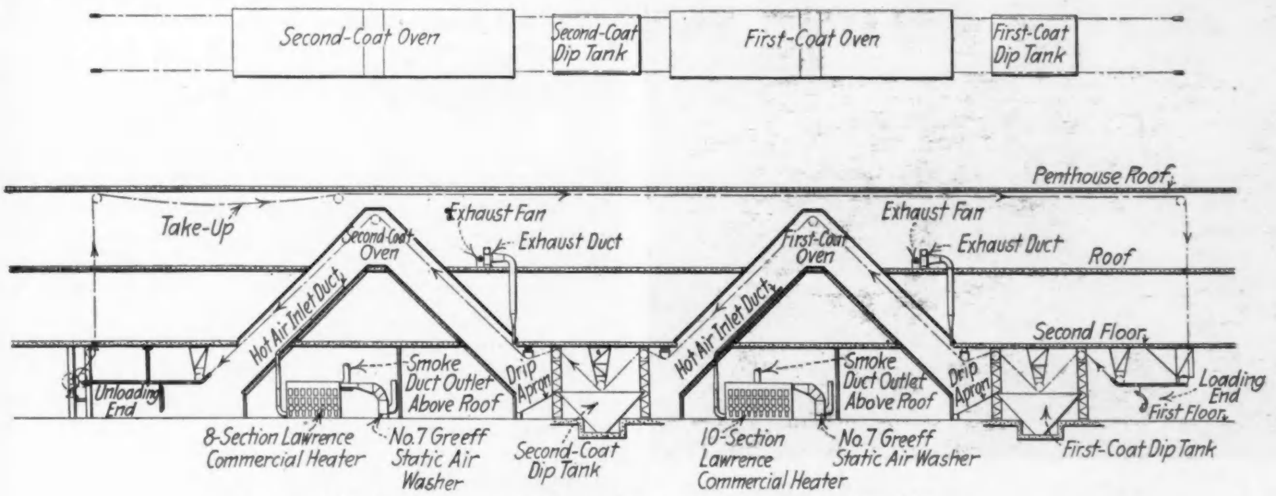

FIG. 8—A FENDER ENAMEL OVEN WITH LONG INCLINED ENDS
In This Oven, Which Is a Modification of That Shown in Fig. 7, a More Positive Trap for the Heat Is Provided, the Length of the Floor Space Occupied Can Be Reduced and a Baking Curve of Almost Ideal Characteristics Is Obtained

These box-ovens were superseded by tunnel-type ovens

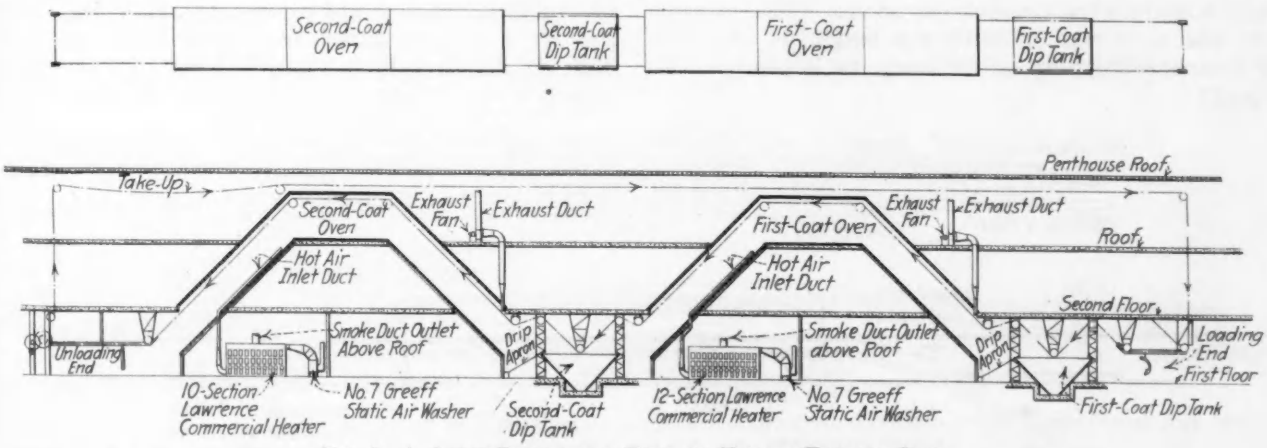

FIG. 9—A LARGE-PRODUCTION TYPE OF FENDER ENAMEL OVEN
This Oven Is Also a Modification of the Earlier Type Shown in Fig. 7. In This Oven, as Well as in That Illustrated in Fig. 8, the Parts Are Gradually Brought from Room Temperature to the Maximum Baking Heat, Are Held at That Point for the Requisite Time and Are Then as Gradually Reduced in Temperature without Any Mechanical Effort

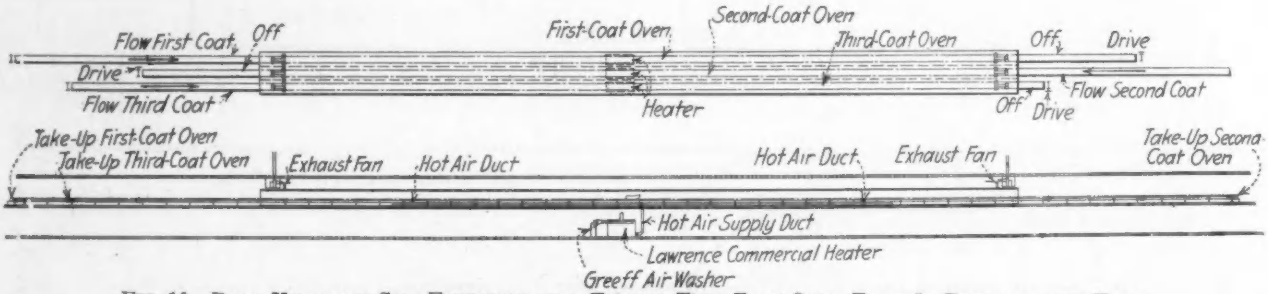

FIG. 10—PLAN VIEW AND SIDE ELEVATION OF A TUNNEL-TYPE BODY-OVEN THAT IS BUILT ON THE FLOOR
In This Arrangement the Ovens for the Three Coats Are Built Side by Side on the Floor. The Ovens Were Approximately 7 Ft. Square in Section and Varied in Length from 220 to 420 Ft. Depending upon the Production Required. The Conveyors Were of the Double-Strand Type with Cross Bars Designed To Tilt the Body Forward To Insure the Enamel Flowing from the Cowl

equipped with power conveyors. In the first four installations of this type of oven a battery of three tunnel ovens was built with the ovens side by side and flat on the floor. These ovens were about 7 ft. wide by 7 ft. high inside and varied in length from 200 to 420 ft. depending on the production required. The arrangement of an oven of this type is shown in Fig. 10. The conveyors were of the double-strand type with cross-bars designed to tilt the body forward, to insure a proper flow of enamel from the cowl. The bodies were placed on the loading end of the conveyor and passed over a flow-pan built into the conveyor structure. The conveyor outside the oven was of sufficient length to secure a fairly complete dripping of the body, as is brought out in Fig. 11.

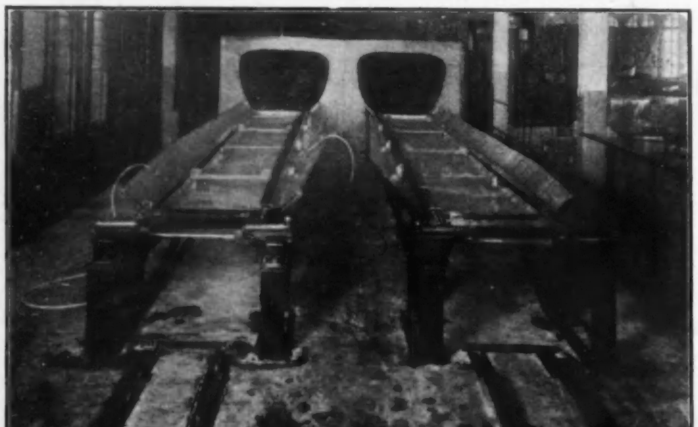

FIG. 11—THE FLOWING END OF THE TUNNEL-TYPE BODY-OVEN
This View Shows How the Conveyor Extends Beyond the End of the Oven, as Illustrated in the Plan View in Fig. 10, a Sufficient Distance to Secure a Fairly Complete Dripping of the Body

This type of oven effected a great saving in labor, material and fuel over the old box-type. The principal objections to it were the difficulty of preventing the escape of smoke and fumes from the open ends of the ovens, inability to control positively the various temperature zones in the ovens due to outside air-currents, and the fact that this type of oven occupied a considerable amount of floor space, though much less than that of a box-type oven of the same production capacity.

The last three batteries of body ovens built by Chevrolet were suspended overhead with the ends inclined to the floor, thereby forming a seal at each end and completely trapping the oven. At two of the plants the ovens are suspended close to the ceiling, leaving sufficient headroom below for storing stock and the carrying on of operations. Figs. 12 and 13 illustrate these ovens. At the other plant, which is a one-story structure, the ovens are suspended from the lower chords of the roof-trusses as shown in Fig. 14. At a fourth plant, a new battery of ovens is being constructed at the present time on the roof of the factory, the inclined ends being brought down through the roof slab to the top floor of the building as can be seen in Fig. 15.

It has been found that this type of inclined-end oven is very easy to ventilate and control, also that the saving of heat is considerable, as no losses are experienced at the open ends of the oven. This oven, of course, requires the minimum amount of floor space.

OVEN-WALL DESIGN

The ideal oven-wall should have a low thermal-conductivity, a low thermal-capacity and the minimum amount of through metal; it should contain the minimum of metallic materials, should form a rugged construction and, if possible, be designed to allow the ready removal of the oven without undue waste of material; it should provide a smooth inner surface to facilitate cleaning and should be completely dust-tight and non-dusting. The first cost of construction should be reasonably low,

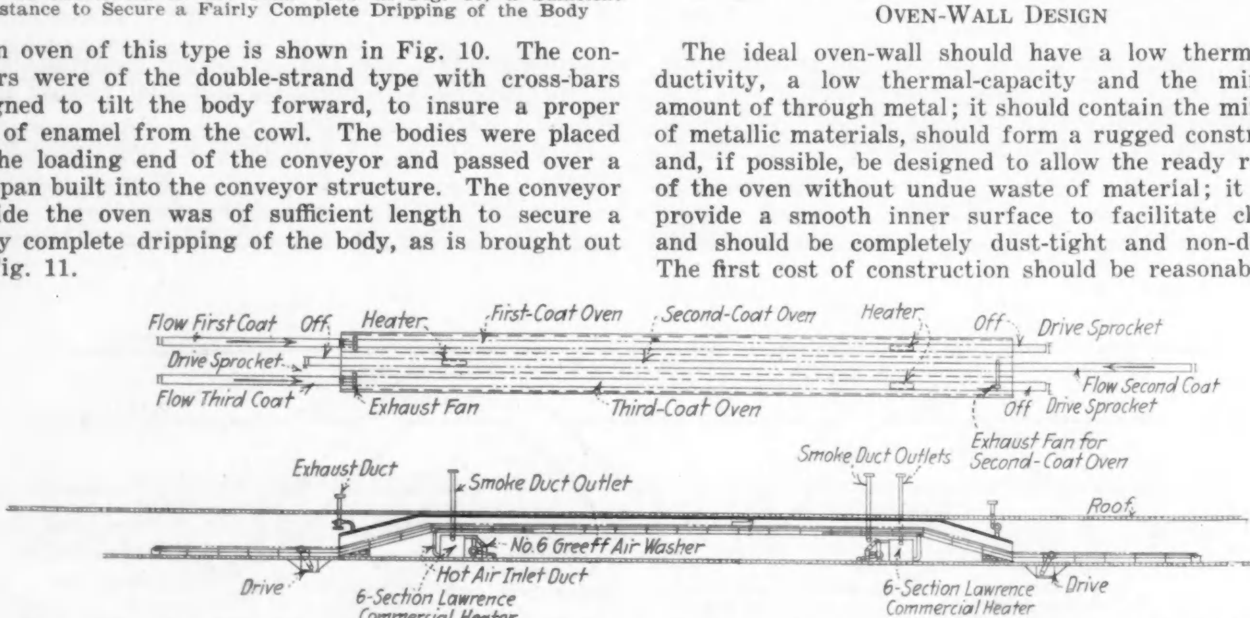

FIG. 12—PLAN VIEW AND SIDE ELEVATION OF A TUNNEL-TYPE BODY-OVEN BUILT AGAINST THE CEILING WITH THE ENDS INCLINED TO THE FLOOR
An Improved Body Oven That Is Suspended from the Ceiling with the Ends Inclined to the Floor, Thus Forming a Seal at Each End and Completely Trapping the Heat. Sufficient Headroom Is Available under the Oven for Stock Storage or Working

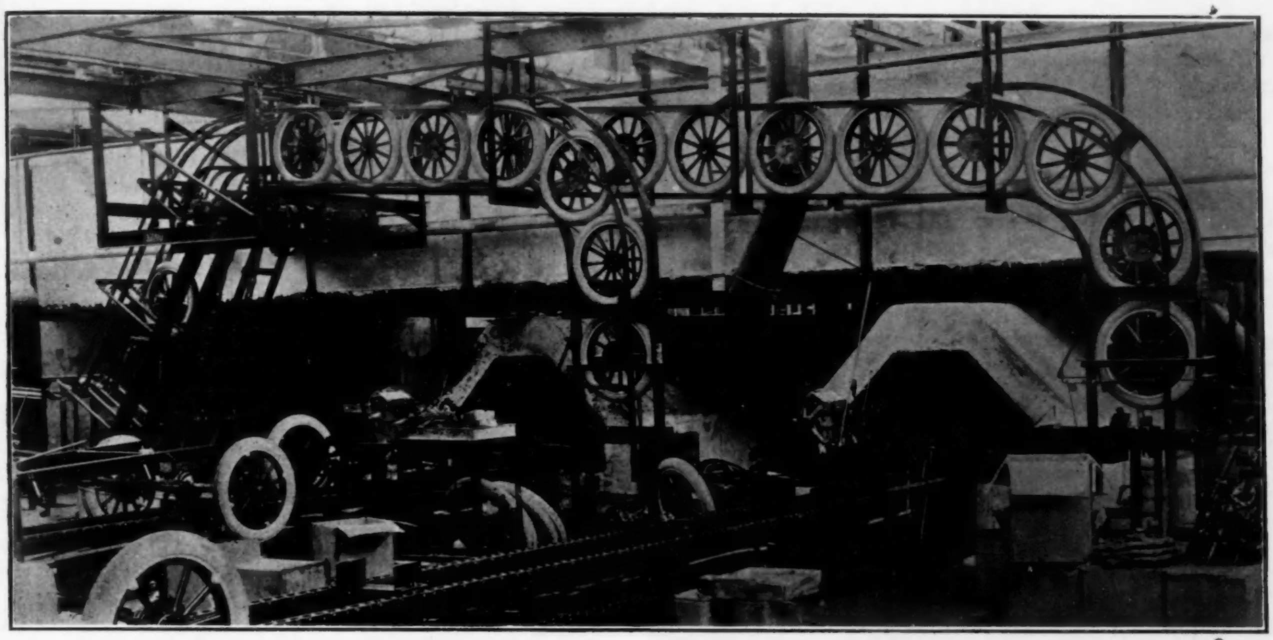

FIG. 14—AN INCLINED-END TUNNEL-TYPE BODY-OVEN THAT IS SUSPENDED FROM THE ROOF TRUSSES OF A ONE-STORY BUILDING
This Oven, Which Can Be Seen behind the Wheel Elevator Extending across the Illustration, Is of the Same Type as That Shown in Figs. 12 and 13. The Chief Difference Is Suspending It from the Roof Trusses Instead of from the Ceiling

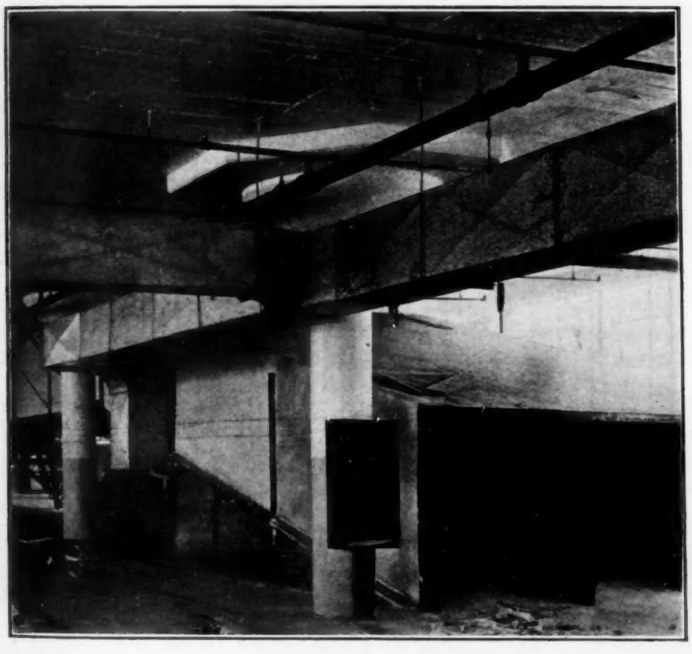

FIG. 13—WHERE THE INCLINED END OF THE TUNNEL-TYPE BODY-OVEN MEETS THE FLOOR
Note the Headroom That Is Available underneath the Horizontal Portion of the Oven for Storing Stock or Productive Operations

that is, the cost should be commensurate with the ultimate efficiency of the wall.

Chevrolet has experimented with and used different types of oven wall. Constructional details of these walls are presented in Fig. 16. The first walls were constructed of 2 by 4-in. pine framing, covered on both sides with 7/8-in. tongue-and-groove siding. This is designated as Section No. 11. Asbestos paper was fastened over the interior sheeting and this in turn was covered with No. 24-gage black sheet-iron. The next type of wall used, Section No. 8, was the "unit-panel" construction. These panels were composed of two sheets of No. 20-gage steel, spaced 2 in. apart, with the edges locked together, the interior of the panel being packed with some sort of insulating material, such as Sil-O-Cel or magnesia. For ovens up to 300 deg. fahr. these panels were used singly to form the shell of the oven. For temperatures around 450 to 500 deg. fahr. the panels were doubled, as in Section No. 10, and a 1-in. layer of asbestos or similar material was placed between them, making a wall 5 in. thick. These ovens were fairly efficient, meeting all the requirements of an ideal wall except that they were costly in comparison with their thermal efficiency. The relatively large amount of through metal at the edges of each of these panels reduced the efficiency and caused the walls to heat on the outside, which was frequently detrimental to operations

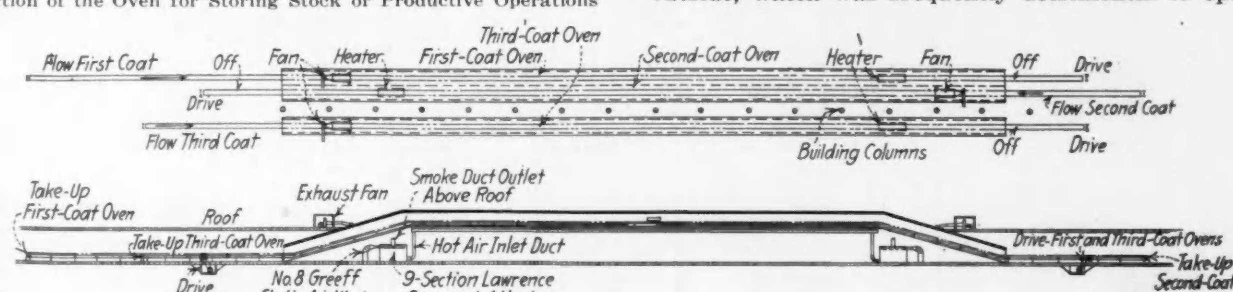

FIG. 15—PLAN VIEW AND SIDE ELEVATION OF A RECENTLY CONSTRUCTED BATTERY OF TUNNEL-TYPE OVENS THAT ARE BUILT ON THE ROOF WITH THE ENDS INCLINED TO THE TOP FLOOR
The Advantages of This Type of Inclined-End Oven Are Ease of Ventilation and Temperature Control, Saving of Heat, Since Losses at the Open Ends of the Oven Are Eliminated, and a Minimum Amount of Floor Space

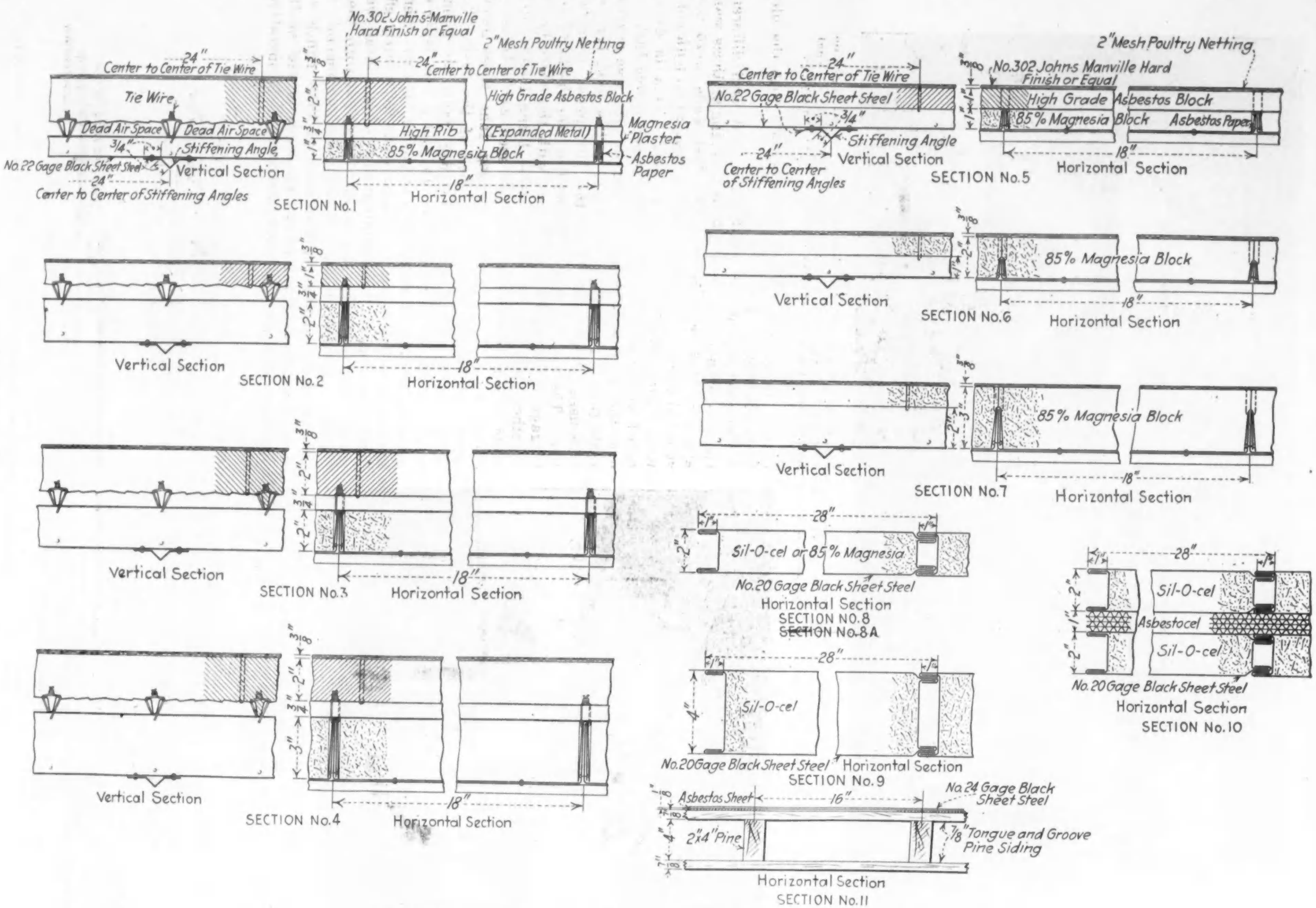

Fig. 16—Various Designs of Oven-Wall Construction Used by Chevrolet
The Patented Wall Construction Used in All Recent Installations Is Shown in Sections Nos. 1 to 4 Inclusive. Sections Nos. 8 and 10 Show the Single and Double Unit-Panel Type Construction Formerly Employed and Section No. 11 Illustrates the Earliest Form Used. The Thermal Capacity of the Different Sections Is Given in the Table on the Facing Page

THERMAL CAPACITIES OF THE VARIOUS OVEN-WALL DESIGNS ILLUSTRATED IN FIG. 16

Section No.	Construction	Thermal Capacity in British Thermal Units per Square Foot per 1-Deg. Fahr. Temperature Difference per Hour — Temperature Difference: 190 Deg. Fahr.	380 Deg. Fahr.
1	As Shown	0.167	0.176
	All Magnesia	0.134	0.141
2	As Shown	0.149	0.157
	All Magnesia	0.134	0.141
3	As Shown	0.125	0.132
	All Magnesia	0.105	0.111
4	As Shown	0.099	0.104
	All Magnesia	0.087	0.091
5	As Shown	0.254	0.265
6	As Shown	0.215	0.228
7	As Shown	0.150	0.158
8	As Shown	0.370	0.375
	All Magnesia	0.225	0.237
9	As Shown	0.204	0.206
10	As Shown	0.147	0.150
11	As Shown	0.314	.....

adjacent to the enameling departments. The outstanding advantage of this type of construction is the ease with which the ovens can be disassembled and reerected in other locations when necessary.

All the ovens recently erected by Chevrolet have been of its own patented wall-construction, as shown in Sections Nos. 1 to 4, inclusive. The inner shell is formed of No. 22-gage standard-width sheets. The edges of the sheets are broken to form 2-in. double lap-joints with the adjacent sheets. The sheets are joined, riveted through the laps and erected in a vertical position with respect to the joints to give structural strength. The inner shell of the floor and the roof is formed in the same manner, except that in the case of wide ovens it is necessary to add stiffening strips at each lap-joint to carry the weight. Two-inch block magnesia is laid against the outside of the sheets and fitted tightly between the outstanding 2-in. joints. Small holes are punched every 12 in. in all joint edges and short lengths of No. 16-gage annealed wire inserted. The wires are twisted once and the two ends left free. Expanded-metal lath is laid against the magnesia block, with the ribs horizontal to prevent excessive convection currents. Annealed wire is used to fasten the lath, a short length of this wire being left exposed beyond the lath. Against the lath is laid another layer of magnesia block. In the case of body ovens, Section No. 1, these blocks are 1 in. thick; on the fender ovens, Section No. 4, they are 3 in. thick. Over this last layer of magnesia 2-in.-mesh poultry netting is tightly drawn and secured with the protruding

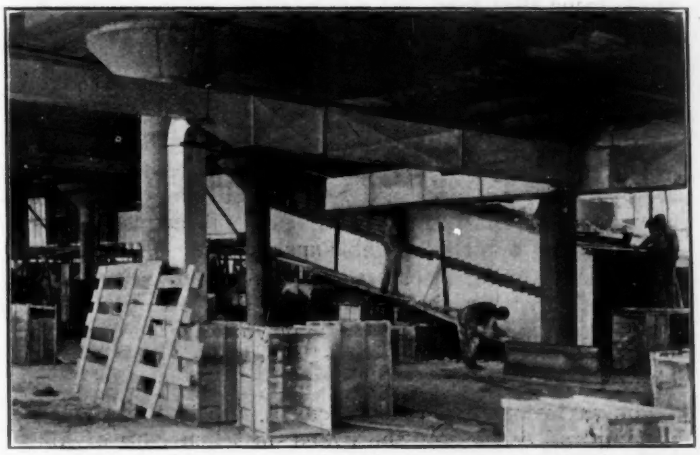

FIG. 17—BODY OVEN WALLS IN COURSE OF CONSTRUCTION
The Sheet Metal, the Expanded Metal Lath and the Outer Layer of Magnesia Block Can All Be Seen in This Illustration. The Construction Is Shown in Detail in Fig. 16

ends of the annealed wire. A ½-in. coat of asbestos plaster is applied over the netting, and then a finishing coat of half-and-half asbestos and cement plaster, which completes the oven wall. Fig. 17 shows this type of oven wall in the course of construction.

These ovens have been found highly efficient. The thermal conductivity and the thermal capacity are exceptionally low; there is no through metal of any kind and only one sheet of metal shell. The cost, in view of the efficiency, is low. The only objection we have found to them is the difficulty and expense of moving the ovens when necessary, but this feature has had to be sacrificed for the sake of the other advantages. It is believed that

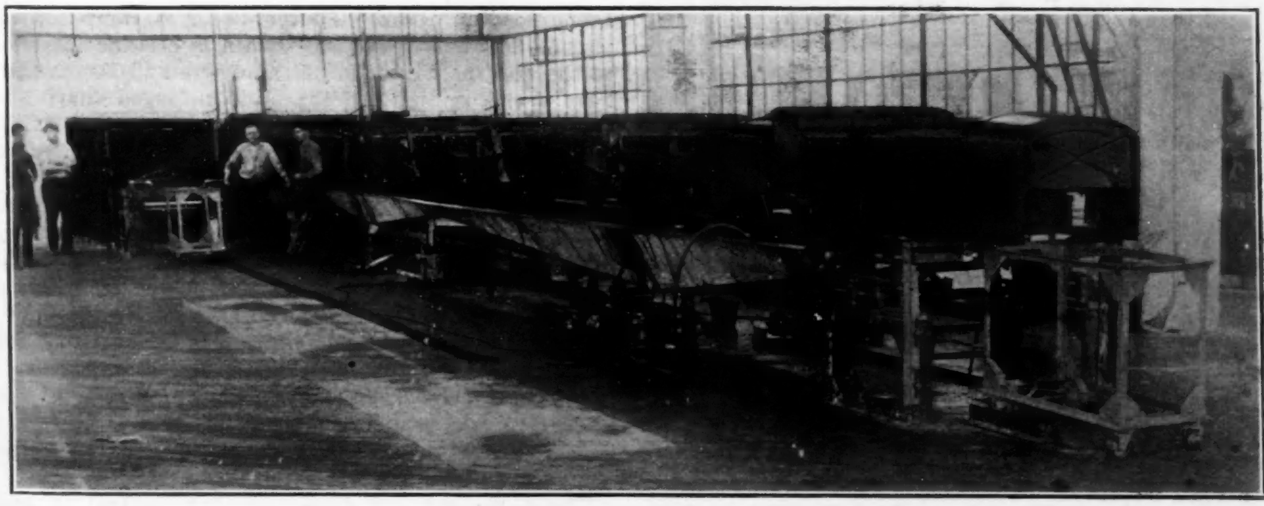

FIG. 18—TYPE OF CONVEYOR USED IN BODY OVENS
The Design of the Body-Oven Conveyor Has Not Been Changed Since the First Tunnel-Type Ovens Were Installed Except for Such Modifications as Were Made Necessary by the Inclined-End Oven. The Body Is Carried on Steel Cross Supports Mounted on Two Parallel Strands of Combination Chain That Slide on the Angle-Iron Frame of the Conveyor. The Loading and the Discharging Ends of the Conveyor Are Designed So That the Body Carriers Pull the Body from the Truck That Brought It to the Conveyor at the Loading End and Deliver It on the Truck at the Discharge End

some means will be devised of making ovens of this type of wall construction more readily movable, but this is one of the several problems we have been unable as yet to solve.

CONVEYORS

The design of the body-oven conveyors has not been changed since the first installation of tunnel-type ovens, excepting the modifications necessary for the later inclined-end oven. As shown in Fig. 18, the body is carried on steel cross-supports mounted on two parallel strands of combination chain. The chains slide on angle-irons that form the conveyor-frame structure. The return chain is carried through the oven on similar angles underneath the upper chain with the body carriers inverted. Bodies are trucked to and from the conveyors at each coat and the loading and discharge ends are designed so that the body carriers pull the body from the truck at the loading end and land it on the truck at the discharge end. Each oven in the battery of three has its own independent conveyor, each being driven by an adjustable-speed motor geared to the head shaft through a spur-gear reduction. Each drive is equipped with a shear-pin safety device to relieve the unit in case of trouble. The conveyors are controlled at both ends by "stop and start" buttons in the motor circuits.

The variation in the chain length, due to the alternate heating and cooling of the ovens, is taken care of automatically by omitting steel slide angles under the return chain for a distance of 20 ft. at the drive end. The chain is stretched taut when cold and after heating expands and hangs freely at this unsupported portion. No

FIG. 19—DETAILS OF FENDER CONVEYOR CONSTRUCTION
These Conveyors, Which Extend from the Loading Room, over the First-Coat Dip Tank, through the First-Coat Oven, over the Second-Coat Dip Tank, through the Second-Coat Oven and Finally into the Unloading Room, Are Modifications of the First Conveyor That Was Designed for the Continuous-Type Oven. Two Parallel Strands of Chain Spaced the Full Inside Width of the Oven and the Tanks and Connected by Cross Bars of Steel Pipe Located 12 In. Apart, from Which the Metal Parts Are Suspended by Hooks, Constitute the Conveyor. All-Steel Machine Chain, by Reason of Its Accurate Pitch, Has Been Found the Most Satisfactory, Although Combination and Drop-Forged Chains Have Been Used with Some Success

trouble is experienced from the expansion and the contraction of the structural support. This suport is built up of relatively short lengths. The head-shaft and tail-shaft frames are secured rigidly to the floor, while none of the intervening steel supporting members are fastened to each other or secured to the floor, except that they are prevented from moving out of line with the center-line of the conveyor by stops on either side. They are each free to move in the line of conveyor travel.

These conveyors are extended a distance of 10 ft. beyond the discharge ends of the oven and 60 ft. at the flowing ends to allow a suitable distance for flowing and dripping before the body enters the oven. This is found highly essential as a complete dripping of the enamel before entrance prevents excessive volatiles in the oven, simplifies ventilation and saves enamel. The upper chains are protected from enamel at the flow-pans by No. 12-gage sheet-iron covers fastened to the upper angle-slides and completely covering this chain.

Lubrication between the chains and the angle-slides is provided by a gravity tank and piping that supply high flash-point oil through wick wipers. All bearings are equipped with Alemite fittings.

Other types of body-oven conveyor have been tried by Chevrolet but this one has proved the most satisfactory to date. Experiments were made with an overhead type of conveyor, in which the bodies were suspended by suitable tackle. It was found difficult to maintain the requisite high standard of cleanliness, on account of dirt falling on the bodies from the moving parts above.

The ideal conveyor is one that will carry the body through all three coats without the necessity for removing the body from the conveyor after each bake and mounting it again to flow-on the succeeding coat. This would be comparatively simple if the three ovens were in a straight line. But large production requirements would necessitate an unreasonably long building to accommodate such a layout and the ovens have been placed side by side. We have been unable as yet to devise a conveyor to do this satisfactorily.

The present fender-oven conveyors are all modifications of the first conveyor designed for the continuous type of oven. These conveyors, a portion of one of which is shown in Fig. 19, extend from the loading rooms, over the first dip-tank, through the first-coat oven, then over the second dip-tank, through the second oven and into the unloading room. The conveyor is composed of two parallel strands of suitable chain, a distance apart equal to the full inside width of the ovens and the tanks. We have used combination chain, drop-forged chain and all-steel machined chain. Each has been satisfactory, though the all-steel chain gives the smoothest action because of its accurate pitch.

Cross-bars of pipe or steel tubing are attached to the chain at intervals of 12 in. These serve to carry the metal parts, which are suspended by suitable hooks. The return chain may be carried back overhead, as in Figs. 7, 8 and 9, or may be returned under the floor slab, as in Fig. 20. Either installation is satisfactory and the proper one should be determined by local architectural conditions. We use the underground-return method when it would be inadvisable to erect a protective penthouse for the overhead-return chain or when some obstruction prevents.

The same sort of drive-unit and control is used as for the body-oven conveyors and the take-up is effected in the same manner by allowing the return chain to sag of its own weight. Lubrication is also obtained in the same way as in the body-oven conveyors.

All sprockets are mounted so that the pitch-circle is 2 in. above the top of the slide-rails. Thus the chains do not slide except on the longest spans under the heaviest loads. The tendency is to carry the entire load on the sprocket bearings, thus reducing the total friction. We have found that this entirely avoids the jerky motion common to conveyors of this type.

Through shafts are used for all sprockets where possible. Where stub shafts are necessary these are securely fastened against rotation and the sprockets are mounted on heavy-duty plain roller-bearings. The cross-bars are free to rotate so that friction between them and the hooks is eliminated, with the attendant possibility of particles falling on the suspended work.

These conveyors have been highly satisfactory. As a suggestion, however, it is believed that the fender-enameling equipment can be arranged so that one conveyor will serve for the purposes of washing, drying, dipping and baking. This, of course, would obviate the present handling between the washing, drying and hanging operations.

As a further suggestion, it is believed that room for improvement in the method of hanging the pieces exists. Each piece should be carefully studied to insure that it will have the best hanging position and that the hooks are designed so that the greatest number can be hung on one bar without interference. Careful thought and effort in this direction will pay large dividends. It costs as much to operate one of these equipments at 80 per cent capacity as at 100 per cent.

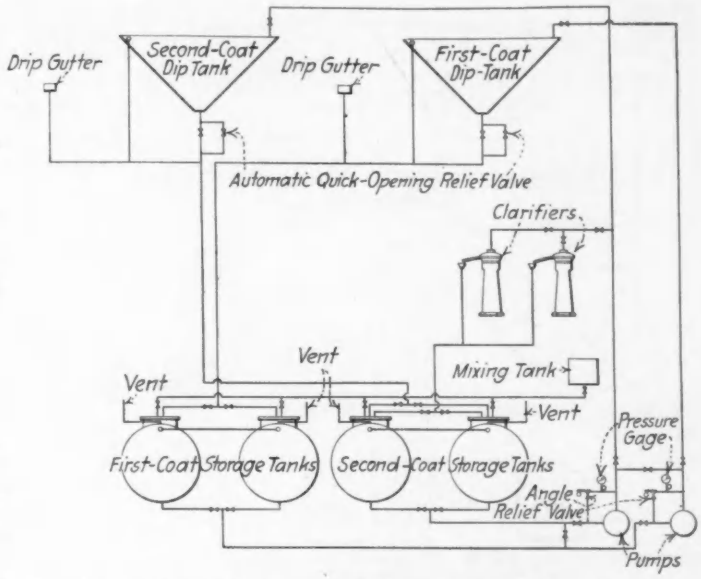

FIG. 21—DIAGRAM SHOWING THE METHOD USED FOR STORING AND HANDLING FENDER ENAMEL

The Enamel Used for the Rubber and the Finishing Coats Is Stored in Cylindrical Tanks on the Floor of the Paint Storage Room Which Have Twice the Capacity of the Dip-Tanks and Are Located So That the Dip-Tanks Can Be Emptied into Them by Gravity in a Very Short Time. The Enamel Is Received from the Manufacturer in Drums That Are Emptied into the Mixing Tank with a Suitable Amount of Reducer. As Soon as the Enamel Is of the Proper Gravity, It Is Emptied into the Storage Tank and Is Then Ready for Use

PAINT-HANDLING EQUIPMENT

All paint and enamel used in the plant is stored in one fireproof room or in a separate building adjacent to the factory. One operator attends to the receiving, storing, mixing and delivering of all paint materials.

The enamel used for the rubber or first coat and the finishing coats on the fenders and the sheet metal is stored in large cylindrical tanks mounted on the floor of the paint-storage room as indicated diagrammatically in Fig. 21. These tanks are each douoble the capacity of the dip-tanks and are at such an elevation that the dip-tanks may be drained into them by gravity through a large pipe-line in a very short time. Over these storage tanks a steel platform is built on which any excess of fender-enamel material is stored in drums. On the platform also are mounted two rectangular open tanks about 2 ft. in height, connected by pipe lines with the storage tanks below. These two tanks are used for mixing. Enamel is received in drums from the maker. These drums are lifted by an air-hoist mounted on a monorail traveler and are emptied into the mixing-tanks together with the suitable amount of reducer. The reducer is stored in the same way as the enamel and is pumped into the mixing tanks; when the reduced enamel is at the proper specific-gravity it is let down into the storage tanks below ready for use.

A pair of enamel clarifiers are mounted on this platform also; they are connected by piping through motor-driven pumps to the finish-coat enamel tanks in such a way that the material in the dip-tanks or in the storage tank can be clarified at any time; the rubber or first coat material is not clarified but is run through suitable strainers in the dip-tank pipe-lines.

A battery of motor-driven pumps is connected with the storage tanks and the material is pumped from these tanks to the dip-tanks above. Large drain lines from the bottom of the dip-tanks are connected with the corresponding storage-tanks below. An adjustable overflow in the dip-tanks is connected with the drain line and prevents the tank from being run over. A by-pass is placed in the drain line around the drain valve. This by-pass line is fitted with a quick-opening valve that opens automatically by a fusible link above the dip-tank

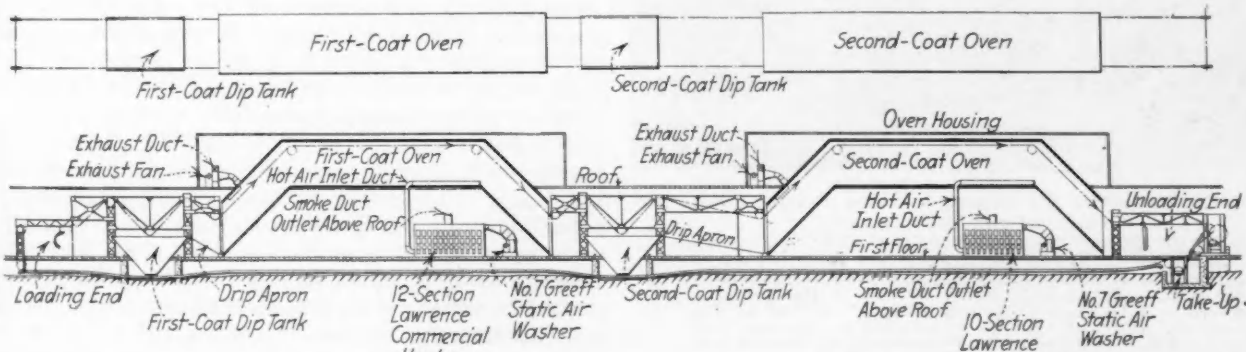

FIG. 20—CONTINUOUS-CONVEYOR TYPE OF FENDER OVEN IN WHICH THE RETURN CHAIN TRAVELS UNDERNEATH THE FLOOR

Either the Overhead or Underground Arrangement of the Return Chain Is Satisfactory. The Latter Is Employed Where It Would Be Inadvisable To Erect a Penthouse To Protect the Return Chain or Some Obstruction Interferes with the Overhead Run

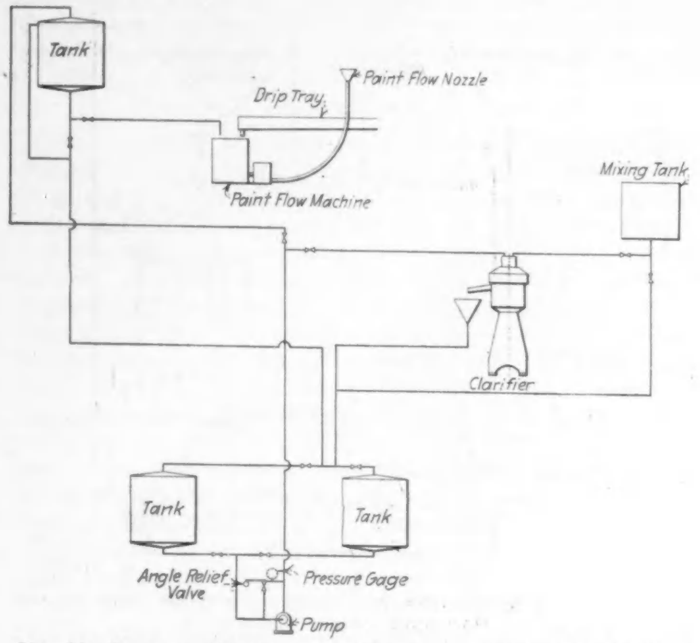

FIG. 22—DIAGRAM SHOWING THE METHOD OF HANDLING THE BODY ENAMEL

The Body Enamel Is Mixed as Required in the Same Way as the Fender Material and Is Pumped into 60-Gal. Storage Tanks from Which It Is Pumped to Tanks in the Body Flow-Room Which Have Overflow and Drain Lines Back to the Storage Tanks. From the Tanks in the Body Flow-Room, the Enamel Is Piped to the Individual Flow-Guns at Each Flow-Pan

in case of fire and quickly drains the dip-tank to the storage tanks below.

We require that the operators drain the first-coat dip-tanks each night after the day's run. The first-coat material is run through a strainer on its way back to the storage tank and again through a second strainer the following morning on its way back to the dip-tanks. The finish-coat material is drained back through the clarifiers once a week and then into the storage tanks. This daily handling of the paint insures absolute cleanliness which is essential to high standards of quality. In addition it produces a constantly uniform mixture of the materials and insures against deterioration.

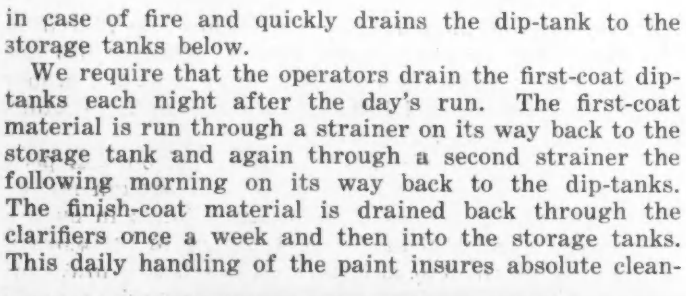

FIG. 23—OIL-FIRED HOT-AIR HEATER AND AIR WASHER UNDER THE FLOOR OF THE BODY OVENS

Each Body or Fender Oven Has Its Individual Heater That Is Located under the Incline of the Oven at the Work-Discharge End. The Air from the Heaters Passes into the Oven at the Floor Level on Either Side. The Supply Ducts Extend to the Center of the Oven and Have a Dampered Opening Every Few Feet So That the Volume of Air Admitted Can Be Controlled at Various Points in the Oven Length. An Exhaust Fan Placed in the Ceiling about 20 Ft. from the Work-Entering End Removes the Cool Air, the Effect Produced in the Oven Being a Slow Circulation of a Large Volume of Air from the Work-Leaving to the Work-Entering End or Opposite in Direction to the Movement of the Body or the Fenders through the Oven

Drip-boards are provided between each dip-tank and the adjacent oven to catch the enamel dripping from the parts emerging from the tanks. The lowest point of this drip-board is connected by piping to the dip-tank drain-line. The inclined floor of the oven nearest each dip-tank is covered with sheets of 1/16-in. asbestos paper to catch the dripping from the reflow that occurs when the parts enter the heated oven. This paper is removed and burned every 3 or 4 weeks. By this means the ovens are kept entirely free from paint accumulation.

The enamel materials used for bodies are stored in the original containers on the steel platform and are mixed as required in the same manner as the fender material. Fig. 22 is a diagrammatic sketch of the method of handling this material. The mixed enamel, when ready for use, is dropped into 60-gal. tanks on the floor below. Clarifiers are provided also for the body-finishing enamel.

The body paint is pumped from this 60-gal. storage-tank to similar tanks in the body flow-room. These tanks are provided with overflow and drain lines back to the storage tanks below. Paint is piped from these tanks to the individual flow-gun machines at each flow pan. The system of handling enamel, as outlined above, insures absolute cleanliness and safety. It prevents waste and provides a centralized and economical method of operation.

OVEN-HEATING AND TEMPERATURE CONTROL

All the box-type body and fender-ovens, as well as the semi-continuous fender-ovens, were heated either with indirect gas-heaters or with electric heaters, most of them with the latter. When these ovens were superseded by the tunnel-type body-ovens and the continuous conveyor-type fender-ovens electric heating was adopted as standard, with one exception. This was a battery of body-ovens that was equipped with high-pressure steam-coils. A small bank of automatically controlled electric-heaters was distributed over the central zone, where the maximum temperature was required and acted as a booster. The oven temperature varied from 150 deg. fahr. at the two ends to 290 deg. fahr. at the center, and the scheme of heating was highly satisfactory as well as more economical than ovens with all-electric heaters.

The heating elements in both the body and the fender ovens were arranged in several circuits. One bank of hand-controlled heaters was constantly on during the operation of the ovens. This bank was of sufficient capacity to bring the temperature of the oven within a comparatively few degrees of the required baking-temperature. The final and exact temperature in each third of the oven was secured by three automatically-controlled banks of heaters that cut in or out as the oven temperatures in each of three zones fell or rose.

The heater circuits were controlled by Leeds & Northrup potentiometer controllers mounted on a central control-board with hand-controlled circuit-switches. These potentiometers were connected with the proper zones in each oven by iron-constantin wire and thermocouples suitably located. The layout for the heating and the control of these ovens was worked out under the advice and the direction of one of the largest electrical manufacturing companies and was highly satisfactory so far as ease of operation and accuracy of control was concerned.

The objectionable features with our particular installations were, first of all, the high cost of fuel. All our plants were paying more than 2 cents per kw-hr. for current and it was felt that the fuel-cost per automobile produced was excessive. In the second place, we had considerable trouble with fires in the ovens, which we attributed to the electric heaters. These were arranged along the walls and the floor of the ovens and were protected with steel-mesh screen. Each heater was connected with the others in the same circuit by cold-rolled steel strips bolted to the heater studs. Each circuit of heaters was connected with the proper cold-rolled bus-bars by similar strips clamped in position with malleable A clamps. This necessitated a great many connections in the oven, and a large number of fires occurred through the loosening of these connections and the arcing of the current. To avoid this trouble, welding of all connections was resorted to, but this did not prove entirely satisfactory, as it was difficult to replace heaters or insulators when they burned out or cracked in service.

Furthermore, the ovens were of necessity cleaned each week, and no matter how great care was exercised it frequently happened that a heater ribbon or an insulator was broken or some other injury done to a heater through carelessness on the part of the cleaners. We came to the conclusion that it was wrong in principle to locate the heating elements within the oven itself, where they would be constantly immersed in a bath of inflammable volatiles.

At the time of writing this paper electric heating has been discarded in all the fender and body ovens of the Chevrolet Motor Co. with the exception of one obsolete battery of semi-continuous fender-ovens that will shortly be removed. All ovens are now equipped with indirect oil-fired hot-air heaters of the type shown in Fig. 23. Each body or fender oven in the battery has its own individual heater, which is located under the incline of the ovens at the work-discharge end. Hot air is admitted to the oven through a suitable duct on either side of the floor of the oven. These supply ducts extend to the center of the oven and are provided with dampered openings every few feet so that the volume of air admitted may be controlled at each point of the oven's length. An exhaust fan is placed in the ceiling of the oven about 20 ft. from the work-entering end and is designed to remove a volume of air equivalent to the quantity pumped in at the heater end. The effect produced within the oven is a slow circulation of a large volume of air from the work-leaving end to the work-entering end and opposite in direction to the movement of the body or fenders.

The heater itself is of the multiple-unit type. Each installation is composed of the number of units requisite to satisfy the thermal requirements of the particular oven that it supplies. Each unit is built up of a number of superimposed cast-iron sections, the bottom section being lined with a refractory material against which the flame impinges. Each unit is provided with an individual burner, to which fuel-oil is forced under pressure by a motor-driven pump.

The combustion gases pass through the heater sections vertically and are discharged through a breeching and a stack at the top. The entire battery of heater units is housed in an insulated casing with a plenum chamber above and below the cast-iron sections. Washed air is supplied by a washer and a fan to the upper plenum-chamber, is forced around the sections down into the lower chamber and thence into the oven.

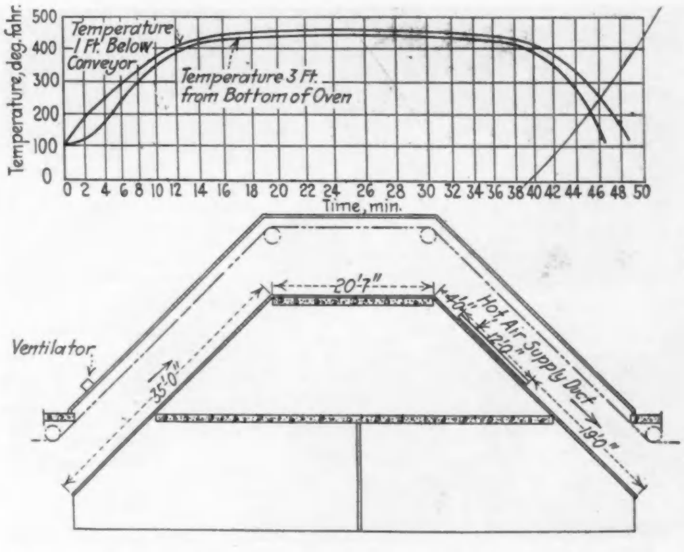

FIG. 24—TYPICAL TEMPERATURE-CURVE IN A FENDER OVEN WITH HOT-AIR HEAT
These Curves Have Been Worked Out as Being Ideal for the Product and the Paint Material Involved and Are Maintained Consistently

Thermocouples placed in each zone of each oven record the temperatures on instruments in the heater rooms. No attempt has been made at automatic control. One operator is required to attend the heaters supplying a battery of both fender and body ovens. This same man regulates the oven temperatures. Regulation is obtained by a valve on the by-pass around the air-supply line to the burners. This valve enables the operator to raise or lower the burner pressure and control the temperature. It has been found that very little attention is required to maintain uniform oven-temperatures.

The first cost of this equipment compares favorably with that of electric heating. The cost of maintenance has been negligible on units that have been in operation under constant full-load duty for about 14 months. The labor operating-cost has been about the same per unit of production as for electric heating, while the fuel cost per unit has been much less. We have had only one oven fire since installing this hot-air heating, and that was in no way connected with the heating equipment. We have noted an improvement in the hardness, the depth and the luster of the baking in each oven in which this heating superseded electric heating. We have also

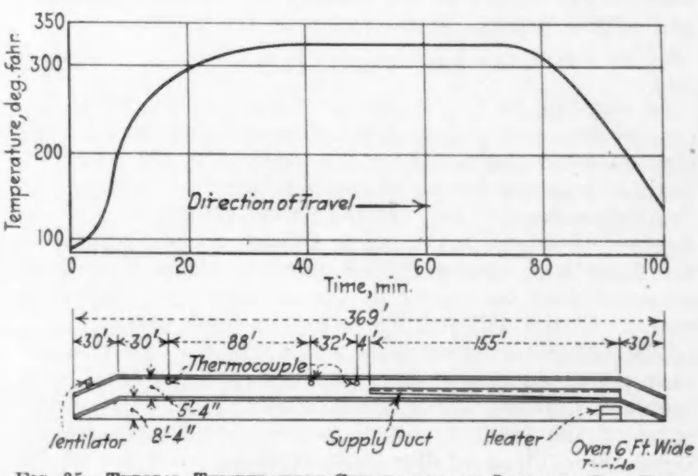

FIG. 25—TYPICAL TEMPERATURE-CURVES FOR AN INCLINED-END BODY OVEN WITH HOT AIR HEATING
Each Paint Material Requires Its Own Special Baking Treatment Which Is a Function of the Time and the Temperature and These Temperature Curves Have Been Worked Out for Each Oven

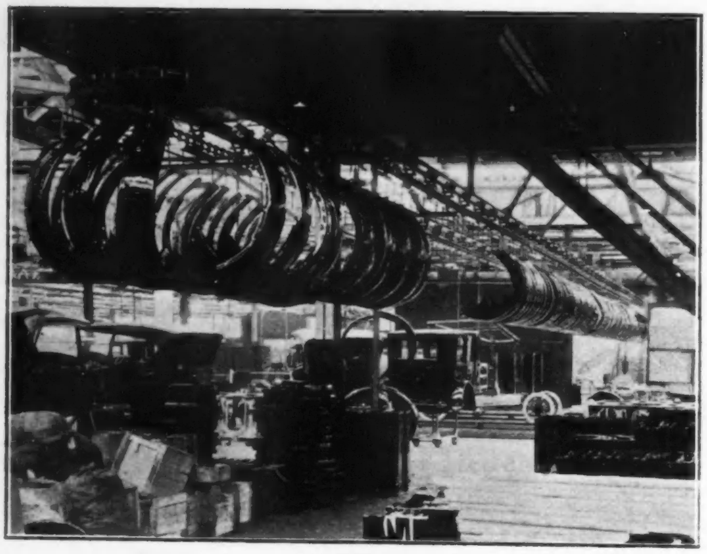

Fig. 26—Type of Overhead Conveyor Used for Delivering Finished Enameled Sheet Metal to the Assembly Lines

These Overhead Conveyors Were Developed To Supplant the Trucking of Enameled Fenders and Sheet-Metal Parts to the Assembly Lines Which Proved Unsatisfactory Because of the High Labor Cost, the Many Rejections as a Result of Injuries in Handling and the Occupying of Valuable Floor-Space by the Trucks. In Addition to Eliminating Trucks and Trucking These Conveyors, Which Run from the Delivery Room of the Fender Oven to the Assembly Lines, Keep All of the Finished Metal Parts Off the Floors and Safe from Injury

been able in every case to increase the rate of production.

The heating equipment that we are now using is still in the development stage. While its use has shown a marked saving over the use of electric current it is felt that this has been due rather to the inherent value of oil as a fuel rather than to the design of the particular equipment.

With reference to the temperature maintained in each oven, it is not felt that this is a matter for discussion. Each paint material requires its own special baking treatment, which is a function of the time and of the temperature. We have worked out for each of our ovens temperature curves that we consider ideal for the product and the paint material involved and typical examples are reproduced in Figs. 24 and 25. With our present heating equipment we are able to maintain these curves consistently. The introduction into the ovens of a large excess volume of air has enabled us to increase the oven temperature and greatly decrease the length of the bake without any injury to the product or the paint material and with a marked improvement in the quality.

Fire Prevention

In addition to the automatic-release valves which, in case of fire, empty the fender enamel dip-tanks into the storage tanks below, these dip-tanks and the adjacent drain-boards are protected with automatic Foamite extinguisher heads that smother the equipment with a blanket of heavy foam. The fender ovens themselves are fitted with open-end high-pressure steam lines that are controlled by valves in the loading and unloading rooms. Steam will smother a fire in these ovens.

The body-oven flow-rooms, which contain only a small quantity of enamel at any one time, are equipped with standard water-sprinkler heads similar to those in other parts of the factory. Open sprinkler-heads are placed along the ceilings of the body ovens at intervals of 10 ft. The control valves are at each end of the flow-rooms. Each oven is divided into three zones, so that only one-third of the oven may be flooded at a time. It has been found that steam will not extinguish a fire in these ovens. The wood in the bodies continues to glow for several hours and bursts into flame immediately upon clearing the oven of steam.

The only oven fire we have had since the installation of hot-air heating was in a body oven and was caused by an oily rag left in a body. Too much stress cannot be laid on the vital necessity for preventing oily or tacky rags being allowed to enter the oven in a wood-frame body, as a fire will certainly result.

Cleanliness

The standard of inspection of our company with respect to the quality of finish of its enameled work is very rigid. This, of course, necessitates perfect cleanliness of the paint materials, the raw product, the equipment and the work-rooms.

An outline has been given in a preceding paragraph of the methods used to insure cleanliness of the paint materials. In addition to the actual straining and clarifying of the paint materials, the fender dip-tanks, the body flow-pans and the paint flow-machines are carefully wiped out each night upon completion of the day's run.

At the end of each week every body and fender oven and every conveyor is cleaned with dry rags and wiped down with a rust-proofing oil. This oil is of a tacky nature and serves to hold any free dust that may float against this equipment.

The floors of the loading and the unloading rooms at the fender oven and the floors of the body flow-rooms are scoured each night with a mechanical washing machine and rubbed down with a coat of paraffin oil. These rooms are partitioned off from the factory and are kept entirely free from suspended dust. This is accomplished by blowing a large volume of washed air into the rooms at several points just above the floor level. A slight static pressure is created in each room by this clean air and it is impossible for dust-laden air to enter through an open door or window. In the event of a door or window being opened, the passage of air is positively outward with respect to the room.

This slight static pressure in the room further serves to render the open-end ovens entirely unaffected by air currents in the building. It more positively prevents the emission of smoke and vapor from the oven ends and provides a highly satisfactory working atmosphere. We are never troubled with bad air in these workrooms and our labor turnover in these departments is low.

Handling of Finished Enameled Parts

As stated in a former paragraph, the discharge end of the third or last-coat body-oven is located adjacent to the receiving end of the body-trim department. Enameled bodies are trucked this short distance, as no more economical method has been devised for handling them.

Enameled fenders and sheet-metal parts present an entirely different problem, as these are used in many different locations in the factory. Trucking of these parts to the assembling lines is most unsatisfactory. The labor cost of handling is necessarily high, the rejections through injuries in handling are many and the trucks occupy much valuable floor space. At present we are installing overhead power-conveyors originating in the unloading room of the fender oven and delivering all these parts to the locations where they are used on the assembling lines. Fig. 26 illustrates a typical example of this type of conveyor. These conveyors enable us to eliminate all the trucks and trucking and in addition allow us to keep all the finished metal stock off the floors and safe from injury.

The Double-Deck Motor Omnibus

By Richard W. Meade[1] Annual Meeting Paper

DOUBLE-DECK horse-drawn buses did not meet with much favor in the United States, but from the earliest days have been popular with persons of all classes in England, probably due in part to the British nation's love of outdoors and in part to the governmental policy of prohibiting the carrying of passengers in excess of the seating-capacity. Packed vehicles continued to be characteristic of transportation in this Country until public service regulation in the early days of the present century required that a reasonable number of seats should be provided. When the number of passengers was limited to the number of seats, at the time of the introduction of motorbuses on Fifth Avenue in New York City, the failure of the experiment was predicted, whereas subsequent service has proved it to be the cornerstone of success. London double-deck buses with 78 seats require about 3 sq. ft. of street space per passenger, while the latest type with 50 seats require about 4 sq. ft. In this Country with the increase in size of the bus the street space per passenger has been reduced from 5 to 3 sq. ft. Private passenger-cars require from 14 to 112 sq. ft. The criticism of slowness of operation that has been urged against the double-deck bus may be largely neutralized by keeping the aisles free and promoting quick loading and unloading. Enclosed upper decks cannot be used in some cities on account of the low vertical headroom due to the presence of overhead railroad viaducts and the like.

Competition in London for the business of the 15,000 cabs and 3700 buses that were in use at the height of the era of horse-drawn vehicles produced a revolution during the years from 1905 to 1908. The result was a merger of the three larger companies and the adoption of a standard chassis embodying the best points of the 28 different types previously used, special attention being devoted to the reduction of weight and noise. As the London police regulations required each vehicle to be presented annually for relicensing, the London General Omnibus Co. instituted the practice of completely rebuilding each of its vehicles during the winter. One of the benefits that resulted was the designing of the various units and the methods of mounting them so that the time of making adjustments and of replacing one unit with another was minimized. Increased operating costs during the war brought concessions from the police authorities regarding carrying-capacity and a type of bus was produced approximating that of the Fifth Avenue Coach Co.'s type L. Development on the Continent did not keep pace with that in England and the United States, the double-deck buses in Paris being replaced by the single deck, while the service in Berlin contained only about 200 double-deck omnibuses.

In 1904 the Fifth Avenue Coach Co. owned about 60 horse-drawn and 13 electric storage-battery omnibuses and was operating at a deficit, only six of the buses having sufficient seating-capacity to operate at a profit. Only 4 miles of streets was used in regular operation and the fare was fixed at 5 cents.

After experimenting with a gasoline-electric system for 2 years, in 1906 a De Dion Bouton chassis equipped with a standard London double-deck type of body was tried and, having been found satisfactory, 14 more chassis were ordered and the bodies were built in this Country to fit them. This same type continued to survive in London after 29 other makes had disappeared. Among its advantages were lightness, minimum unsprung weight, forced-feed lubrication, low consumption of fuel, single-disc clutch and general excellence of material and workmanship. Its disadvantages were automatic poppet valves and no direct drive on high gear.

In 1908, with the extension of the service over Riverside Drive, a bus having double the capacity of those previously in service was tried and 25 additional ones of this type were then ordered. In them modifications of London practice were introduced, including drop windows, a storage-battery for lighting, folding doors, electric signal-bells, push buttons, a heating system supplied from the engine exhaust, illuminated roller-curtain signs, double hand-rails for safety and a windshield for the driver. Horizontal tubular-type radiators were substituted for the honeycomb type. Further simplification was made later by the use of semi-floating axles, steel wheels and standardized steel-base tires and by improving the quality of the tires. About 1910, Moline Knight sleeve-valve engines were first tried and have proved very successful.

Refinements that have recently been added to meet the requirements of other cities in which bus service has been introduced include the reduction of the height to enable buses to pass under low viaducts, the increasing of the capacity to 67 passengers, rubber shock-absorbers instead of spring shackles, a generator for lighting that makes it unnecessary to carry a large battery for this purpose and a regulator that prevents overcharging. In the effort to avoid complications the use of the fixed spark has been considered as indispensable. An important improvement that remains to be developed is the enclosed upper deck with a covering of the nature of a one-man top. When this has been produced it will give the bus an all-weather all-season capacity that will put it in its rightful place in the scheme of transportation.

Among the factors that are suggested for guiding the future design of the bus are safety, maximum comfort and convenience of the passenger consistent with a reasonable occupation of street space, minimum operating cost and maximum safe speed. Steam, generated by low-grade fuel, is predicted as the future motive power.

THE double-deck omnibus as a horse-drawn vehicle had very little vogue in the United States. It was common practice in the days of horse-drawn omnibuses to place the driver high to give him a better command of the situation. Sometimes a seat or two was located beside him and, rarely, a bank of seats behind him, but the bus with a full deck of seats, either *en banc* or *dos-à-dos* seems never to have appealed to managers of omnibus service in this Country any more than the double-deck car has been regarded by our street-railway operators as a desirable vehicle for their use.

Not so in Europe. From the earliest days in England, stage carriages carried about as many passengers on the upper deck as inside and, as the city omnibus developed with its bank of seats on the roof, those places became popular with persons of all classes and have remained so to this day. To what extent this feature of English omnibus design sprang from the Briton's inherent love of outdoors and to what extent to the en-

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lightened regulatory policy of the government, in prohibiting the carrying of passengers in excess of the licensed seating-capacity, that has prevailed from the earliest days, I do not know. There is reason to believe that it was due to both, in combination with the superior commercial instinct of the stage-carriage proprietors. Necessity is ever the mother of invention. Being restricted to the number of passengers for which they had seats, they managed to provide the maximum number of seats that could be placed on a vehicle of practical dimensions by superimposing on the roof a number equal to or greater than those in the interior and were thereby able to offer to their customers the kind of seats that many preferred. Thus was developed a principle in the design of vehicles for city transportation, whether bus or tram, that has a basic economic advantage, especially in these days of street traffic congestion, over any form of single-deck equipment.

Enlightened regulation of city transportation services being wholly absent during the formative period both of omnibus and of railcar systems in the United States, seats meant nothing to our local transportation managers and their vehicles were packed with as many passengers as could find standing or even clinging room. With the advent of electric traction, dimensions and capacity increased and were used to the limit. It was not until well along in the first decade of the Twentieth Century that the introduction of public service regulation forced an outraged industry to provide, during specified periods, a reasonable number of seats in proportion to the whole traffic carried. So when, just at the dawn of that era, with the establishment of motor-omnibus service on Fifth Avenue, New York City, I introduced the innovation of carrying only the number of passengers for whom seats were provided, I was regarded by "practical" street-railway men as an idealist, and predictions of failure of the experiment were freely expressed. That basic rule, voluntary on our part, has been the cornerstone of the success of the Fifth Avenue Coach Co. and of all the subsequent motorbus services that have been patterned upon it. Of course there was necessity for it in the use of equipment of the most limited weight and dimensions, but these considerations might readily have been disregarded just as they have been in the establishment of several other motorbus services using double-deck equipment in various parts of the United States, all of which either have disappeared entirely or have fallen into financial difficulties.

Street Space Occupied

I remarked above that the double-deck vehicle had a basic advantage from the point of view of street congestion over any single-deck equipment. The London double-deck bus with its 78 seats occupies but little more than 3 sq. ft. of street space for every passenger seat, and that is exactly the space required to be provided for each standing passenger carried in street cars by some of our more enlightened public utility commissions. Even the double-deck Broadway car that appeared on the streets of New York City somewhat more than 10 years ago occupied but $4\frac{1}{2}$ sq. ft. for each passenger seat, but that car was expected to carry the ordinary standing load and seating accommodation was sacrificed to that and also to an unnecessary restriction in the overall height, which was less than 13 ft. Against this the single-deck car occupies anywere from 6 sq. ft. for the Birney one-man car to $9\frac{1}{2}$ sq. ft. for the cars of some systems whose prosperity is regarded by their managers as depending on the straphanger. The double-deck motorbus has developed in this Country to a point where instead of requiring nearly 5 sq. ft. for each seat in the original 34-passenger vehicles, it now requires only slightly more than 3 sq. ft. in the latest vehicles of large capacity. Against this, the latest type of bus developed in London, seating 50 passengers, requires slightly less than 4 sq. ft. per passenger seat.

Comparing further the space required per passenger seat, in addition to that of the driver, by the privately-owned or public-hire automobile, we find, as might naturally be expected, the more extravagant use of 12 to 14 sq. ft. for the seven-passenger car and 15 sq. ft. for the Ford five-passenger car. If the number of passengers usually carried in such cars in the congested districts of large cities at the rush hours is considered, which averages $1\frac{3}{4}$ including the driver, the contrast is still more marked, rising from 83 sq. ft. for the Ford to 112 sq. ft. for cars of larger size, these figures being for each passenger carried in addition to the driver.

Street-railway men always urge against the double-deck car that it is too slow in operation, and if operated according to their customary practice it probably would be, but if no passengers beyond the seating capacity are admitted, thus keeping the aisles free for circulation, and with a proper design of aisles and stairway, I am convinced that with a little judicious education the public would learn to use such a car in a way that would make it fully as quick in operation, under peak-load conditions, as the better types of American single-deck equipment, for the improvements designed to promote quick loading and unloading are usually neutralized by the difficulty and delay experienced by passengers in forcing themselves into and extracting themselves from the car when its aisles are crowded with standing passengers. A double-deck car built with the utmost lightness consistent with the necessary strength to carry a seated load should have an operating cost no greater than that of a single-deck car able to carry standing the same number of persons, while the earning power of a full complement of such equipment, designed to be as attractive as the recent types of buses, should be greater than the single-deck vehicle, because of the added business that would be developed during the non-peak hours.

An insuperable physical obstacle to the operation of double-deck cars with enclosed upper decks exists in some of our cities, or at least over some routes, in the presence of overhead railroad viaducts of low vertical clearance. The London County Council's double-deck street-car is more than 16 ft. high, but it should be possible to reduce this materially, though it should not be done by such devices as are employed in the New York car above alluded to, namely, the *dos-à-dos* arrangement of seats on the upper deck and the character of lower-deck design that caused the single-deckers of this type to be called "submarines"; if such features are embodied the labors of the designers will be in vain, for no such car will be popular.

The fact is, of course, that the double-deck street-car has never had a fair trial in the United States. The results obtained from the operation of a single car or even of several cars interspersed with a regular service of single-deckers and all operated on the "always-room-for-one-more" plan is never a fair criterion of what can be done with a full service of really attractive equipment.

London's Experience with Early Motorbuses

The application of mechanical power to the double-deck vehicle accentuated its value from the point of view

of the conservation of street space, though the full possibilities of this development were a long time in being realized in the case of the bus. About 1904, French and German engine factories began to turn their attention to the design and construction of cabs and buses. London, being the greatest field for the employment of such vehicles and having services of 15,000 cabs and 3700 buses at the height of the era of horse-drawn vehicles, became the battleground of builders and promoters both to capture the business of the old established companies and to enter the field as operators of the new type of vehicle. Probably no such revolution in the transportation service of a city has ever occurred elsewhere as took place in London during the years 1905 to 1908. The bulk of this service, at least in the central districts, was in the hands of several large omnibus companies and of a number of lesser and individual omnibus proprietors, all of whom worked in harmony, or at least understanding, with each other. The motorbus promoters and builders found the old established companies conservative in the idea of replacing their equipment with something regarded as highly expensive and experimental. These companies had always earned comfortable profits. The London General Omnibus Co., the largest, having upward of 1400 buses, made net earnings as high as $450,000 a year and paid 10½-per cent dividends. They did not feel inclined to scrap their existing investment and were slow to respond to the arguments of the promoters and builders of motor equipment as to the fabulous profits that could be made with it. Now the operation of a bus in London is open to anyone who can present to the Commissioner of Police of the Metropolitan District a vehicle that meets his approbation for operation over the route on which it is proposed that it shall ply, so the promoters and builders turned their attention in that direction and began to form motorbus companies and place individual buses in service on some of the choicest routes of the city, with the result that the old companies, seeing their business being taken by the motorbuses, were forced in self-defense to adopt motorized equipment. In the beginning, any vehicle that did not appear actually dangerous in operation was permitted temporarily for experimental purposes, but the commissioner, Sir Edward Henry, an especially capable and intelligent official, was not long in calling to his assistance some of the most eminent automotive engineers. Following out in principle the established practice with respect to horse vehicles, he directed them to prepare specifications for both the chassis and the bodies of motor cabs and motor omnibuses, with which operators must comply before they could secure licenses to ply on the streets of London. When these specifications were issued they took all the joy out of life for most of the builders and promoters, who pronounced them impossible of compliance. But Sir Edward was unmoved by the clamor and, beyond permitting the continued operation experimentally of certain less objectionable types that did not comply and permitting some minor variations from the specifications, continued to serve notices on the various proprietors "not to use" any bus that was excessively heavy or too large or that made too much noise or that had defective brakes, steering-gears, transmissions, wheels, tires and the like. Slowly but surely the builders evolved buses that came within the weights, dimensions and other specifications, and out of it all came the most efficient city-transportation system in the history of the world and one that today continues to be a model that in many respects has never been surpassed.

But during the years 1905 to 1908, a battle royal was waged between the two principal horse bus companies and the principal new motorbus company that turned the London General Omnibus Co.'s annual profit into a deficit almost as large, forced some of the lesser companies into bankruptcy and culminated in a merger of the three larger companies into the new London General Omnibus Co. The first of the fruits of peace was the establishment of manufacturing facilities on a large scale and the design and production of a chassis embodying all the best points of the 28 makes that had from time to time been used in the service of the several companies. The type-B chassis that was the final evolution of this movement continued to be the standard of that company up to and throughout the war period, although a chassis produced by the English Daimler Co. fitted with a Knight sleeve-valve engine was also introduced just before the war.

London Motorbus Specifications

The specifications for motorbuses formulated by Worby Beaumont for the commissioner of police and somewhat modified in 1909, controlled the design and the construction of motorbuses in London until after the war. They applied to a double-deck bus seating 16 passengers on longitudinal benches inside and 18 passengers on transverse benches on the upper deck arranged on either side of a central aisle. How radical the weight limits were may be judged from the fact that many of the earliest vehicles presented for license weighed 11,000 lb. or more. A summary of these specifications is given below:

The limit of weight, unloaded, was 7840 lb., for the chassis, with body mounted, or alternatively, the weight on the rear axle when loaded, must not exceed 8960 lb.; and on the front axle 4480 lb.; or a total of 13,440 lb., including passengers and crew and water, gasoline and other supplies on board, 140 lb. per person being allowed in the computation of this weight.

The length over all must not exceed 23 ft.; the width, 7 ft. 2 in.; the height, from the ground to the center of the roof, 9 ft. 3 in.; the height of the inside of the body, 5 ft. 6 in. to 6 ft.; and the ground clearance of every part of the vehicle except the wheels, 10 in.; the object of this prescription being apparently to avoid further injury to the body of a person who had been knocked down and got under the bus.

The springs must not be nearer together, from outside to outside, than 45 in. for the rear and 38 in. for the front. The wheel-track for both pairs of wheels must coincide and be not less than 5 ft. 6 in., and in no case must the front wheels be less than the rear. The wheelbase must not be more than 14 ft. 6 in. and must be proportioned so as to prevent skidding. There must be at least two independent brakes, each capable of holding the vehicle under all conditions. They must have a compensating device capable of easy adjustment. At least one of them must be applied by a foot-pedal. Brakes were not considered independent if they acted through the same connections, upon the same brake-locks or upon the same brake-drums, and at least one of them must act on the road wheels without any connection with the propelling gears. No brake must cause declutching.

The machinery must be constructed so that no undue noise or vibration would arise from its use. Lubrication and carburetion must be controlled so that smoke would not be emitted. Provision must be made to prevent the dropping of oil and grease on the roadway. Guard rails around the upper deck must be at least 3 ft. high and 18 in. above the highest part of the seat. Sixteen-inch width must be allowed for each passenger and 26-in. knee-room between the seats.

Outside of the weight, the provisions that caused the greatest difficulty to the builders and the operators under this order was the prohibition of undue noise. Many thousands of buses were ruled off the streets for this cause. Engines, transmissions and final drives, either of the chain or internal-gear type, were responsible for most of the trouble and anyone not familiar with the commercial vehicle of that day would find it difficult to believe how hideous the noises emitted, even by the best of them, could be. The resulting development of a bus that was "dangerously silent" again illustrates that old adage about necessity's progeny. Change-gear boxes, worm axles and remarkably quiet poppet-valve engines were incorporated into the type-B chassis.

Hand in hand with the production of a vehicle that would meet these exacting requirements went the development of a chassis that could be kept in service the maximum number of days in every year. Under the London police regulations every public carriage must be presented yearly at Scotland Yard for relicensing and, at that time, to secure the desired certificate, must be in good order mechanically, freshly painted and varnished and its upholstery and fittings in presentable condition. Under these requirements, the London General Omnibus management instituted the practice of completely rebuilding each of its vehicles annually, doing most of this work in the winter, so as to avoid holding the buses out of service in the season of maximum earnings. The chassis was completely stripped and all results of wear or damage made good, every part in reassembling being brought up to the latest standard. The body was completely renovated, so that the vehicle when presented for licensing was as good or better than it was when new. This annual reconstruction, taken in conjunction with a fortnightly overhaul based on mileage performed, gradually eliminated most of the police notices "not to use" and gave the company an intensive use of its equipment that brought large earnings. The design of the various units and the methods of mounting them so as to minimize the time of making adjustments and of replacing one unit with another contributed in the most important degree to economy of maintenance. I do not believe that industrial history can show a better illustration of the economic value of intelligent regulation coupled with a more efficient response on the part of the regulated. Honor is due to the men concerned on all sides in this splendid achievement. We owe the great success we have made in this Country with the double-deck motorbus and the comfort and pleasure we have given millions of persons to the way they blazed.

Post-War Development in London

During the war omnibus development in England was at a standstill and operating costs rose so high that profit became impossible under existing fares. The commissioner of police was appealed to to allow the same maximum dimensions and weights that applied to other commercial vehicles to be extended to motorbuses, thereby permitting an increase in seating-capacity. His approval was finally secured and new regulations were issued that sanctioned a development similar in principle to that of the Fifth Avenue Coach Co.'s type L. In the meantime, the designing staff of the London General Omnibus Co. had brought out in 1919 what was known as the type K which, within the limiting dimensions of the regulations of 1909 for 34-passenger buses, and practically within those weights, provided seats for 46 passengers, 22 on the lower and 24 on the upper deck. This was accomplished by placing the driver beside the engine, saving $3\frac{1}{2}$ ft. of length. This type was followed in 1921, upon the relaxation of the regulations, by the S type, just under 25 ft. long and still within the old width-limit by an inch and weighing about 10,000 lb. The S was followed in turn last spring by the NS, designed as a low-level bus with the declared purpose of making it an all-weather omnibus by the addition of a roof-covering whenever the commissioner permits such an innovation. It is 26 ft. overall, weighs 11,172 lb. without load and carries a seated load of 50 passengers. This vehicle has some particularly interesting features. Its wheels are 41 in. in diameter, which should, of course, make for easy riding, as against the 34 and 36-in. wheels used under American low-level buses. Its final drive is a reversed worm in combination with double-reduction internal gears. It has a constant-mesh gearbox with helical gears and a multiple-disc clutch. Since the war, great progress has been made by the London General Omnibus Co. in the art of building bodies, both in methods and in the use of new and improved materials, by which weight is reduced without sacrifice of strength.

Double-Deck Buses on the Continent

Development of the double-deck bus on the continent of Europe has not kept pace with England or with the United States. With the appearance of the motor vehicle, the Compagnie Generale des Omnibus of Paris established a service of about 150 Brillie double-deckers with seats arranged *dos-à-dos* on the upper deck or "imperial" as it is termed, over which was spread a canvas canopy with curtains for use in the event of rain. The upper-deck places were of the second-class as on the horse-drawn buses, and the fare was just one-half that of the first-class places on the lower deck. My recollections of riding on the upper deck of these buses is as disagreeable as that of the London buses is pleasant. With uncomfortable seats, narrow aisles with others pushing by, curtains on a rainy night and with no way of seeing where one was, this service was short-lived, being replaced by the single-deck vehicles that unquestionably were designed as much for war purposes as for the peaceful transportation of passengers in Paris.

Berlin had before the war, in addition to a large fleet of horse-drawn buses, a service of more than 200 double-deck motor omnibuses. These were of the Daimler, Büssing and Nürnberg Actien Gesellschaft makes, having seats for 39 passengers on transverse benches, arranged two on one side and one on the other side of the aisle; the seats on the upper deck were similarly arranged but with the double seats on the opposite side to preserve the balance. In these buses one bank of seats was over the driver, but none were over the rear platform.

Early Bus Operation in New York City

When I took the management of the Fifth Avenue Coach Co. at the end of 1904, it owned about 60 horse-drawn omnibuses, mostly of archaic type, and 13 electric storage-battery buses. It had a franchise of unlimited term over 19 miles of streets, of which only 4 miles was in regular operation. The company had lost money consistently throughout its life, and since storage-battery vehicles had been in operation, its operating expenses for the 2 years just passed had exceeded its revenues by $40,000 in each of those years without allowing anything for the depreciation of the equipment. The fare for its horse-drawn-bus service over the 4 miles between Washington Square and 89th Street was fixed at 5 cents, but its franchise permitted a 10-cent fare for any service performed by motor vehicles.

Out of the entire equipment, just six vehicles had sufficient seating-capacity to operate at a profit over the 4-mile route with a 50-per cent load. These were double-deck horse omnibuses of the standard London type, seating 20 passengers on each deck; and it is a striking example of the disdain in which anything of foreign origin was regarded by transportation men in this Country that two of these vehicles had never been in service, their left-hand stairways not having been modified to suit our rule of the road. I lost no time in having them changed, and during the remaining 2½ years of horse operation they always paid their way, though they entailed the employment of a conductor and required three horses instead of two. With a full equipment of that character and the employment of a heavier type of horse than we used, the historic unprofitableness of the Fifth Avenue stage line might never have existed.

The immediate and pressing need of the company was for some form of motorbus capable of operating profitably over that 4-mile route. Its secondary need was for equipment for the operation of the remainder of the system, involving an extreme haul, from Washington Square to 155th Street, of 8½ miles.

The company's disastrous experience with the storage battery, not only on buses but on cabs and other vehicles, eliminated it from consideration. It had cost the parent company more than $4,000,000, though the loss had not been written off, to learn that that system of motive power, with a string always tied to it, was ill-adapted to the public transportation of passengers, in which the successful operator, whether of cabs or of buses, must be able to respond instantly and continuously, not only to the rapidly changing needs of the public but to their whims and caprices, without reference to the condition of the battery or other source of power in any particular unit of his system.

This was the period when the gasoline motorbus was still in the experimental stage on the streets of London, where about a dozen such vehicles were in operation. Upon taking office I found a proposition from the General Electric Co. for collaborative production of a motorbus employing the gasoline-electric system. We promptly accepted the invitation, and the most valuable result obtained from it was my association with James S. Anthony, assistant to President Griffen, a highly intelligent young engineer, whose intimate knowledge of the latest European developments in commercial motor traction was of the greatest value to us. After a canvass of the situation we quickly agreed that the double-deck London motorbus was the solution of the Fifth Avenue problem. As our board did not at that time favor the importation of a complete vehicle and as body builders in this Country were unfamiliar with the design and construction of double-deck bodies, we decided to try out the gasoline-electric system on a single-deck vehicle. Our joint production was a shocking contraption from every point of view, but it proved the practicability of the system, though not its economy, for that has never been equal to straight mechanical drive. We followed the experiment out later on a more extensive scale with double-deck vehicles, but a loss of about 20 per cent in power always resulted, and the mechanical gear-box improved so rapidly in a few years that there was no longer the excuse for the electric transmisson that existed in 1904.

Importation of the First Chassis

In the meantime, developments had been rapid in London and by the end of 1905 our board had been induced to authorize the importation of a De Dion Bouton chassis equipped with a standard London double-deck body. This did not arrive until the middle of 1906. Its practically perfect performance in 6 months of daily service on Fifth Avenue, driven by Edward Wotton, now equipment engineer of the Yellow Coach Mfg. Co., the eagerness of the public to secure passage on it, and their delight over the experience of a ride on its upper deck "sold" the proposition to our board, who, before the end of 1906, authorized the purchase of 14 more chassis of the same make and the construction in this Country by the Chinese copy method of bodies to fit them. The chassis were imported "knocked-down" to Philadelphia, assembled in the body plant, the bodies mounted and, the first "drive-away" of motorbuses in this Country having been successfully accomplished, service was commenced on Fifth Avenue about the end of July, 1907, on a 5-min. headway. This service was an immediate and pronounced success and from that day to this the Fifth Avenue Coach Co. has in every year earned a handsome return on its investment. The impression that it ever lost money or even failed to earn a high return is erroneous and results from the fact that during the early years of motor operation depreciation of the equipment was charged on a 3-year basis and a reserve for injury and damage claims was set up at the rate of 3 cents per bus-mile. These charges, which subsequent history showed to be far in excess of what was necessary, were established as a policy of conservatism, no experience being available at that time to show how long such vehicles would last in New York City service nor what our casualty experience would be. Some of the omnibuses that were thus depreciated during the years 1908, 1909 and 1910 are still in daily service on Fifth Avenue and today are in every respect standard with the rest of the equipment. In other words, no particle of the material composing the original vehicle, which, unit by unit, has disappeared, as exhaustion or obsolescence has required its replacement, remains in them.

The selection of the De Dion Bouton chassis, which was made against negative reports by two English automotive engineers, was most fortunate, saving the company, at the lowest estimate, several hundred thousand dollars in operating expenses, and I am glad to give the major credit to Mr. Anthony, who, a few years later, died an untimely death, and to Leonard K. Clark, who, after 2 years experience in the operation and maintenance of motorbuses in Birmingham, England, in the very infancy of the art, had joined us as mechanical engineer. An interesting vindication of our judgment was furnished later in the fact that the London General Omnibus Co. continued its 150 De Dion buses in service long after all the other 29 makes had disappeared.

The specific features of the De Dion Bouton chassis that led us to select it as against several other makes were:

(1) Lightness, combined with great strength, notably in the composite wood and steel flitch-plate frame
(2) Minimum unsprung weight, free from the final chain drive so common in those days, due to its unique type of internal-gear axle with a separate weight-carrying member
(3) Its system of forced-feed lubrication of the engine by a pierced crankshaft, at that time a rarity in engine design
(4) Its low consumption of fuel, due in part to its lightness and general excellence and in part to its Zenith carbureter

(5) Its single-disc clutch, than which nothing better has ever been designed for motorbus service. This had a metal-to-metal contact, later modified by us by substituting a fabric lining for the De Dion bronze, the remarkable quality of which we were never able to duplicate in this Country

(6) The general excellence of its material and workmanship, which were as fine as anything in European manufacture

Against these advantages, the De Dion Bouton bus of that day had automatic poppet-valves and no direct drive on high gear. The high-pitched "singing" of its gears might be heard blocks away. Both these features were eliminated in the next year's model.

Extension of the service over the system after this first success was by no means rapid. To the conservatism of the Company's directors, a majority of whom wanted to hand back to the City all the route franchises in Harlem, was added the misguided zeal of a park commissioner who prevented the extension of the service over Riverside Drive during his term of office. The first act of the late Judge Gaynor on assuming the mayoralty was to open that famous parkway to "the poor man's automobile." But the popularity of the service brought a 200-per cent increase in equipment in 1908, 33 per cent in 1909, 30 per cent in 1910, 30 per cent in 1912, 18 per cent in 1913, 10 per cent in 1914, 15 per cent in 1917, 60 per cent in 1918 and 17 per cent in 1919, reaching high-water mark in 1922 with 296 buses.

Departures from London Practice

With the first winter operation over extended routes, we began to feel the need of more interior seats than the 16 provided in the London type of body, so when the General Omnibus Co. of Paris in 1910 introduced its single-deck buses of 31 and 35 seats we imported a smaller type of De Dion to try it out. For nearly a year this bus was run in regular service and its earnings compared with those of its leader and follower were indications that appeared so favorable that we ordered 25 of these chassis. While this test was in progress, I had the good fortune, while in Europe in the summer of 1911, to secure the services as mechanical engineer of G. A. Green, who had had a most valuable experience in the service of the London General Omnibus Co., rising rapidly from depot superintendent to assistant chief engineer and works manager. On his recommendation these chassis were equipped with double-deck bodies, with seats for 22 on the lower deck and 23 on the upper, for which the chassis had ample strength. The results of operating with this increased capacity were most satisfactory, and thus occurred our first radical departure from London practice, for these vehicles weighed complete 11,620 lb., of which 7620 lb. was in the chassis with its bracketed body supports. Incidentally, this chassis, having a wheelbase of less than 12 ft., could turn in a 43-ft. circle, a most important advantage to any bus used for city service.

Modifications of London practice began with the first bodies built here, the initial change being to make the windows drop. Storage-batteries for electric lighting instead of acetylene; a folding door of the telephone-booth type; electric signal-bells for the conductor instead of a bell cord and, later, push buttons at each passenger's seat; a heating-system supplied from the engine exhaust; illuminated roller curtain signs, showing both the route and the destination; double handrails on the stairway to the upper deck for safety; windshields to protect the driver; then side doors and windows for his cab; these were some of the improvements that added comfort but also weight. The first chassis unit that required modification was the radiator, the honeycomb type becoming leaky under the heavy service on New York City pavements. For this the Kells radiator having round horizontal tubes of copper was substituted and has proved the best for omnibus service that we have ever been able to develop. It is rugged, freezing seldom causes damage and, if a tube does burst or become leaky, the mere insertion of a cork, of which a supply is always kept on hand, stops the trouble instantly and is effective until the bus comes in for its fortnightly overhaul. These advantages overbalance the comparatively inefficient cooling qualities of this type as compared with the fin and honeycomb varieties.

In the early days, wheels and tires gave no end of trouble. Metal wheels, except cast iron of enormous weight, were not to be had in this Country. The wooden wheels would dry out in hot weather and become creaky. If soaking was not sufficient, the wheel must be rebuilt. That involved taking off the tire fastenings, expanding and removing the tire band, removing the iron band that held the wood together and then reversing the whole process after repairs had been made. Each tire manufacturer had his own kind of band and method of attaching the tire, so that any change in the make of tire involved complications; and tires at times were so unreliable that they caused many delays and tie-ups of equipment. In 1 year our tire expense was nearly 5 cents per bus-mile. The mere removal and replacement of the wheels in those days was something of a job. The simplification that has been wrought by semi-floating axles, steel wheels, standardized steel-base tires and the vast improvement in the quality of the tires themselves are things that one who did not go through the grief of pioneer days can hardly appreciate.

The first engine of 105-mm. (4.133-in.) bore and automatic valves was succeeded by another De Dion of 110-mm. (4.341-in.) bore, and again by a third of 120-mm. (4.724-in.) bore, all being of 130-mm. (5.118-in.) stroke. In 1910 appeared a long-stroke engine of 110-mm. (4.341-in.), a great advance in power and flexibility, and very silent and smooth-running except at high speeds. It was about this time that Samuel Rea, president of the Pennsylvania Railroad Co., began calling my attention, periodically, whenever I met him, to the qualities of the sleeve-valve engine that seemed to him to make it the thing for our service. So when I met C. Y. Knight and Percy Martin of the English Daimler Co., builder of the Moline Knight engine that had appealed so strongly to Mr. Rea, just after a successful test had been made of it at the Automobile Club of America, and they both urged me to secure one of the engines to try out in our service, I requested Mr. Green to do so. He was bitterly opposed at first but soon became enthusiastic and from that time to this has been progressively improving that engine so that today it is unquestionably the best engine yet developed for bus service.

On the outbreak of the war in 1914 the French Government commandeered 25 motorbus chassis, which were being built for us in France and for which bodies were being built over here. We canvassed all the leading builders of motor trucks in this Country to ascertain whether they would supply us with chassis built according to our specifications, including Moline Knight engines. Most of them were too busy with war orders to consider our comparatively small order, but one of them was willing to do it if we would accept his engine, a thing that we declined to do. Then we canvassed the

parts makers and secured component parts for our chassis and built up 25 assembled jobs for the bodies that were on hand. These had flitch-plate frames, Moline Knight engines, inverted worm-drive, standard De Dion-type single-plate clutch and steel wheels, of which we had imported a number from Europe shortly before the war. The next step was to commence the construction of our own bodies and to reconstruct 45 of our De Dion Bouton chassis, making them strong enough to carry a 44-passenger body. From this point the construction in our own shops of our own equipment proceeded and a program of 200 new standard chassis and bodies to be known as type A was commenced.

The type-A chassis as developed at that time did not differ radically from the majority of the equipment operated by the Fifth Avenue Coach Co. today, the most important subsequent change being the increase in capacity to carry a 51-passenger body in place of a 44. The original A-type had the flitch-plate frame of vanadium steel with ash filling, the progressive spring, one of the most important improvements of that day, final worm-drive, four-speed gear-transmission, single-plate disc clutch, semi-floating axles, steel wheels with roller bearings, Moline Knight engine, thermosiphon cooling and boiler-tube radiators. A radical improvement has, however, been made in the construction of bodies since that time, tending both to lightness and to strength, as well as to general appearance.

Expansion to Other Cities and Improvements in Equipment

In 1913, in company with some associates, I secured the first certificate of convenience and necessity for a bus route in Chicago, covering the Lincoln Park district. The Fifth Avenue Coach Co. would not take any interest in such an enterprise and we planned to secure our equipment from the English Daimler Co., which at that time was closely allied with the London General Omnibus Co. But before we could secure our franchise the war intervened. Our certificate was taken up by one of the rival applicants, Roland R. Conklin, the first American capitalist that saw the possibilities of the motorbus business and was willing to get behind it. He secured the services of Charles O. Ball, formerly in the mechanical department of the Fifth Avenue Coach Co., and the latter after some unsatisfactory development of gasoline-electric vehicles, designed a tractor-trailer type of double-deck bus seating 51 passengers that had a roof only 8 ft. above the pavement and could therefore operate safely under the low railroad viaducts so common throughout Chicago. The vehicle had serious weaknesses of design but accomplished an important purpose and was an epochal step forward in the art. While this vehicle was still in the construction stage, Mr. Conklin conceived the idea of securing a franchise in New York City in competition with the Fifth Avenue Coach Co. So aggressive was his campaign that I induced my board to allow me to "carry the war into Africa," whereupon we organized the Chicago Stage Co., which became an applicant for bus rights over all Chicago. To convince the Illinois Public Utilities Commission that we were better able to serve than Mr. Conklin's Chicago Motorbus Co. it was necessary to produce before them a vehicle that was capable of operating safely under the Chicago viaducts. Such a vehicle was designed and constructed in a remarkably short space of time during the summer of 1917. It had a reversed-worm axle drive, a side entrance, inside stairway and other features of design of which we were none too proud. Its roof was several inches higher than theirs, which was most unfortunate but, as in many another corner of this kind, Edward Wotton's ingenuity and resourcefulness came to the rescue. By pitching back its upper-deck seats to such an extent that the top of a passenger's head was 6 in. lower than it would have been on the normal type of seat, the condition was met and our bus *looked* to be about one-half the size of the Chicago Motorbus Co.'s vehicle. On presentation to the Utilities Commission it won their approval, and we received the certificate for the South Side of Chicago which was simultaneously refused to the Chicago Motorbus Co. This decision was, however, appealed and thereupon we proceeded seriously to design a low-level bus that resulted in type L, which with various modifications and improvements has become the latest standard of the Fifth Avenue Coaach Co.

All through this period we were deprived of the services of Mr. Green, who, being a loyal subject of King George, had joined the British Tank Corps with the rank of captain. The design of type L therefore devolved largely on Reuben E. Fielder, who acquitted himself most creditably.

At the beginning of 1919, I became president of the Detroit Motorbus Co. and the type-L bus being by that time pretty well tried out, I secured the first of them as a demonstration vehicle. It proved the best argument that could be given the rather skeptical people of Detroit that a motorbus service in that city might be not only useful but profitable. The success of that service from the very day it was started has been pronounced and must make some of the critics, who denounced my ultra conservative estimates of traffic and profit as extravagant, feel rather sheepish.

One of the cleverest and most useful improvements yet devised in connection with the double-deck bus is the semi-cover invented and produced by A. E. Hutt, now of Philadelphia, who was superintendent of the Detroit Motorbus Co. during its first 2½ years. Some of Detroit's viaducts have but 12½-ft. clearance. It was desirable to have a cover for the upper decks of our buses, yet to be able to operate them under the viaducts. The problem seemed insolvable, but the idea of leaving the aisle uncovered was as simple as Columbus' egg.

Of the developments of the last 2 years several stand out prominently. The production of practical vehicles carrying upward of 60 passengers is by far the most important, for it pushes the bus a long step farther into the field of mass transportation. The first vehicle of this character was developed by Charles O. Ball while chief engineer of the American Motorbus Co., and was a highly creditable achievement, especially under the conditions under which it was produced. The greatest compliment that could be paid to it was its practical adoption as the basis of the standard vehicle carrying 67 passengers produced by the Yellow Coach Mfg. Co., which, with the many improvements and refinements that it embodies, constitutes a new landmark in the development of the double-deck bus.

One of the most valuable innovations of recent years is the substitution of rubber shock-insulators of the Mack type in place of spring-shackles. A minor improvement of great operating value is the development, after years of hard, discouraging work, of a generator for lighting purposes that makes unnecessary the carrying of a large battery for that purpose with all the difficulty and expense of daily removal, recharging and replacement. The final detail that seems to assure the accomplishment of the purpose is the development of a reg-

ulator that prevents over-charging, making the set practically automatic and foolproof.

And here let me remark that an important element of success in the operation of motorbuses lies in the avoidance of complications. Mr. Ford told me once, as I suppose he has told many others, that a large part of his time is spent in keeping "improvements" from being added to the Ford car. It has been much the same with the motorbus. The elimination of every detail that requires special attention to keep it functioning is desirable, unless that function is of the greatest importance. The fixed spark, which since the very infancy of the motorbus has been regarded as indispensable, is an example of just this thing, because the variable spark was subject to more abuse by incompetent or careless drivers than any other one thing.

Another important development of recent years, and one that never yet has had a thorough trial, is that of the enclosed upper-deck. In that improvement lies, in my opinion, the development of the double-deck bus into its rightful place in our scheme of transportation, giving it an all-weather, all season capacity and, if our traction managers are wise and our city authorities and public utility commissions well advised, the standee and the strap-hanger will become things of the past in city transportation, and comfort will arrive. The bus so equipped will, of course, lose something of its lure for those who love the open air and sky and sun. The development I have always aimed at and hope yet to see accomplished is something in the nature of a one-man top that can be spread or furled instantly. Used in conjunction with drop windows of the light flexible transparent unbreakable glass that we shall have in due time, this will make an ideal covering.

Controlling Factors for Future Design

In suggesting the controlling factors that should guide in future motorbus design, I can not do better than refer again to the paper by Mr. Green entitled Principles of Motorbus Design and Operation that he presented at the 1922 Semi-Annual Meeting of the Society, a careful rereading of which I commend to those interested. In that paper he states those factors[3] as follows:

(1) Safety
(2) Comfort and convenience of the public
(3) Minimum operating cost

But with respect to the second factor, I would modify it to read "maximum comfort and convenience of the passenger consistent with a reasonable occupation of street space." I refer specifically to the necessity for controlling the overall dimensions of the motorbus as well as that of all other vehicles permitted to use our streets, especially public vehicles. Our city and State authorities having been very remiss in this matter, it devolves on the industry itself to exercise restraint in the interest of the general welfare. With the enormous increase in vehicular traffic in cities, conservation of street space is too important to permit luxurious or obstructive dimensions in public vehicles. We may well be guided in this matter by the conservatism of London.

[3] See The Journal, July, 1922, p. 14.

With respect to the third controlling factor, minimum operating cost, I cannot emphasize too strongly the importance of the sub-factor, maximum safe speed, as brought out by Mr. Green. Much of the attraction and usefulness of the multiple carrier is lost if it cannot get from point to point with reasonable celerity as compared with other means of transit. One of the greatest values of the motorbus to American cities today is its ability to eliminate the employment of a large number of private automobiles in daily use to and from business, shopping, and the like, together with the concomitant abuse of the parking privilege in congested districts that has become a cancer in our traffic problem. If reasonable speed cannot be offered these persons, they will not be attracted by the bus. Then, as pointed out by Mr. Green, the predominating elements of operating expense are vitally affected by the overall speed of the service, so that the motorbus to be successful must be capable of the greatest possible sustained speed consistent with the safety and comfort of its passengers and of the public at large, and with reasonable wear and tear on the vehicle itself.

One of the lessons that may be learned from the history of the development of the motorbus is that it has been the operators of these vehicles who have been responsible for most of the progress that has brought the vehicle of today to its high efficiency. The scrap heap has been largely their guide. They have had in their daily services great working laboratories that have run off the most searching tests in the shortest possible time, and the operation of the laboratory has been profitable instead of being an expense. No ordinary manufacturer could afford to put his product through the same process of test, and the information he secures from his customers is seldom of a character comparable with the results secured in closely supervised operation. The surprising fact to me is that some of the great industrial organizations of this Country which employ large fleets of motor vehicles have not taken a leaf out of the motorbus operators' books and undertaken the design and the construction of vehicles more definitely fitted to their specific needs. When they commence to do this, if it is well done, advances in the efficiency of the truck comparable with those that have been attained in the bus will be made.

What will be the motive power of the motorbuses of the future? I shall be greatly surprised if steam, generated by low-grade fuels, does not soon come into its own. With its infinite flexibility in the application of power, it ought to be the ideal source of propulsion for heavy road-vehicles. Having commenced my transportation experience with steam as the prime-mover, I am prone to return to my first love. If one-half the time, the capital, the energy and the intelligence that have been devoted to the internal-combustion engine had been given to steam for the propulsion of road vehicles, is there any doubt that it would be far in advance of its present position? Think of the reduction of effort on the part of the driver that could be accomplished! The constant running of the engine and the lost time and motion of gear changes are wasteful in the extreme, but we tolerate them because at this time the explosion engine has "the jump" on other forms of motive power.

Personnel of 1924 Standards Committee

THE designation of the Standards Committee personnel for this year has been completed, but the Society is still awaiting replies from a number of those asked to serve as to whether they will accept appointments. The work of the several Divisions will proceed in a normal manner, however, as the 1924 Divisions commenced their term immediately following the Annual Meeting of the Society that was held in Detroit on Jan. 22 to 25. The Standards Committee this year will be constituted of 28 Divisions, one more than during the first part of last year, the additional group being the Tire and Rim Division.

This year the representation on a number of the Divisions has been extended to include men who are in charge of servicing automobiles and accessory apparatus, as a careful survey last year of the importance of standardization in the service field has demonstrated that without doubt this has become one of the important branches of the automotive industry through which the value of the Society's standardization work can be brought more forcefully to the attention of the manufacturers' executives, and through their greater appreciation of its values, lead to a more extensive practical application of the Society's standards.

As heretofore the Divisions that are active during the year will be supplemented by Subdivisions appointed to consider and report to their respective Divisions on specific subjects that are assigned to them. Although some Divisions will be relatively inactive during the year, it is considered advisable to have them organized now to take up any work that may be assigned to them at a later date. The number of appointees on this year's Standards Committee exceeds that of last year's committee by approximately 20 per cent.

The following appointees to the Standards Committee were approved by the 1924 Council of the Society at the meeting in Detroit on Jan. 23, and had definitely accepted their appointments by Jan. 29.

STANDARDS COMMITTEE

E. A. Johnston, *Chairman*

C. M. Manly, *First Vice-Chairman* C. C. Carlton, *Second Vice-Chairman*

AERONAUTIC DIVISION

H. M. Crane, *Chairman*	Consulting Engineer
H. L. Pope, *Vice-Chairman*	Wright Aeronautical Corporation
W. L. Gilmore	Curtiss Aeroplane & Motor Co., Inc.
L. M. Griffith	National Advisory Committee for Aeronautics
Otto H. Hamm	Air Service
J. L. Harkness	L. W. F. Engineering Co.
Grover C. Loening	Loening Aeronautical Engineering Corporation
E. C. Richard	Air Mail Service
William B. Stout	Stout Metal Airplane Co.
B. Douglas Thomas	Thomas-Morse Aircraft Corporation
R. H. Upson	Aircraft Development Corporation
Edward Wallace	Glenn L. Martin Co.
L. M. Woolson	Packard Motor Car Co.
Paul G. Zimmerman	Aeromarine Plane & Motor Co., Inc.

AGRICULTURAL POWER EQUIPMENT DIVISION

J. F. Max Patitiz, *Chairman*	Allis-Chalmers Mfg. Co.
O. W. Sjogren, *Vice-Chairman*	University of Nebraska
J. B. Bartholomew	Avery Co.
C. E. Frudden	Hart-Parr Co.
A. H. Gilbert	Rock Island Plow Co.
R. O. Hendrickson	J. I. Case Plow Works Co.
Pliny E. Holt	Holt Mfg. Co.
E. T. Maguire	Knox Motor Co.
A. W. Scarratt	Minneapolis Steel & Machinery Co.
G. A. Young	Purdue University
O. B. Zimmerman	International Harvester Co.

AXLE AND WHEELS DIVISION

C. C. Carlton, *Chairman*	Motor Wheel Corporation
C. S. Dahlquist, *Vice-Chairman*	Timken-Detroit Axle Co.
R. S. Begg	Jordan Motor Car Co.
T. V. Buckwalter	Timken Roller Bearing Co.
R. J. Burrows	Clark Equipment Co.
H. E. Derr	International Harvester Co.
E. V. Elconin	Eaton Axle Co.
F. W. Gurney	Gurney Ball Bearing Co.
F. P. Hall, Jr.	Salisbury Axle Co.
G. W. Harper	Columbia Axle Co.
E. R. Jacobi	Hayes Wheel Co.
G. L. Lavery	West Steel Casting Co.
D. D. Ormsby	Brown-Lipe-Chapin Co.
H. Spur	Russell Motor Axle Co.
S. O. White	Warner Gear Co.

BALL AND ROLLER BEARINGS DIVISION

F. W. Gurney, *Chairman*	Gurney Ball Bearings Co.
T. V. Buckwalter, *Vice-Chairman*	Timken Roller Bearing Co.
J. T. R. Bell	Rollway Bearing Co., Inc.
G. R. Bott	Norma Co. of America
H. E. Brunner	S. K. F. Industries, Inc.
E. R. Carter, Jr.	Fafnir Bearing Co.
D. F. Chambers	Bearings Co. of America
L. A. Cummings	Standard Steel & Bearings, Inc.
F. G. Hughes	New Departure Mfg. Co.
R. G. Schaffner	Bower Roller Bearing Co.
W. R. Strickland	Cadillac Motor Car Co.
R. E. Wells	Hyatt Roller Bearing Co.
H. Wickland	U. S. Ball Bearing Mfg. Co.

CHAIN DIVISION

H. S. Pierce, *Chairman*	Link-Belt Co.
W. J. Belcher, *Vice-Chairman*	Whitney Mfg. Co.
D. B. Baker	International Harvester Co.
G. M. Bartlett	Diamond Chain & Mfg. Co.
W. F. Cole	Baldwin Chain & Mfg. Co.
H. F. L. Funke	Herbert F. L. Funke Co., Inc.
K. L. Herrmann	Studebaker Corporation of America
M. C. Horine	International Motor Co.
J. C. Howe	American High Speed Chain Co.
F. L. Morse	Morse Chain Co.

ELECTRIC VEHICLE DIVISION

J. G. Carroll, *Chairman*	Walker Vehicle Co.
H. M. Pierce, *Vice-Chairman*	Ward Motor Vehicle Co.
G. L. Bixby	Detroit Electric Car Co.
A. K. Brumbaugh	Autocar Co.
E. L. Clark	Commercial Truck Co.
C. H. Meeker	Lansden Co., Inc.

ELECTRICAL EQUIPMENT DIVISION

F. W. Andrew, *Chairman*	Eisemann Magneto Corporation
T. L. Lee, *Vice-Chairman*	North East Electric Co.
C. R. Alling	Underwriters' Laboratories
Azel Ames	Kerite Insulated Wire & Cable Co.
F. A. Bonham	Durant Motors, Inc.
S. W. Colvard	Dayton Engrg. Lab. Co.
A. M. Dudley	Westinghouse Electric & Mfg. Co.
P. J. Durham	P. J. Durham Co., Inc.
S. F. Evelyn	Continental Motors Corporation
C. F. Gilchrist	Electric Auto-Lite Corporation
W. S. Haggott	Packard Electric Co.
A. D. T. Libby	Automotive Electric Association
Charles Marcus	Eclipse Machine Co.
E. A. Robertson	Splitdorf Electrical Co.
B. M. Smarr	General Motors Corporation
C. H. Williams	Studebaker Corporation of America
Ernest Wooler	Cleveland Automobile Co.

ENGINE DIVISION

R. J. Broege, *Chairman*	Buda Co.
W. C. Ware, *Vice-Chairman*	Fay & Bowen Engine Co.
A. A. Bull	Northway Motor & Mfg. Co.
P. J. Dasey	Wellman-Seaver-Morgan Co.
W. V. DeGalan	Paige-Detroit Motor Car Co.
R. F. Droege	Templar Motors Corporation
S. F. Evelyn	Continental Motors Corporation
J. B. Fisher	Waukesha Motor Co.
Pliny E. Holt	Holt Mfg. Co.
A. F. Milbrath	Wisconsin Motor Mfg. Co.
M. J. Steele	Packard Motor Car Co.
Joseph Van Blerck	Joseph Van Blerck Engine Corporation

FRAMES DIVISION

C. C. Bowman, *Chairman*	Standard Motor Truck Co.
O. B. Harmon, *Vice-Chairman*	Parish & Bingham Co.
R. S. Begg	Jordan Motor Car Co.
E. A. DeWaters	Buick Motor Co.
W. A. McKinley	Detroit Pressed Steel Co.
Ernest Wooler	Cleveland Automobile Co.

IRON AND STEEL DIVISION

F. P. Gilligan, *Chairman*	Henry Souther Engineering Corporation
J. M. Watson, *Vice-Chairman*	Hupp Motor Car Corporation
J. R. Adams	Midvale Co.
R. J. Allen	Rolls-Royce of America, Inc.
H. T. Chandler	Vanadium Corporation of America
B. F. Courtright	Wisconsin Steel Works, International Harvester Co.
J. D. Cutter	Climax Molybdenum Co.
L. A. Danse	Cadillac Motor Car Co.
C. N. Dawe	Studebaker Corporation of America
B. H. DeLong	Carpenter Steel Co.
E. W. Ehn	Timken Roller Bearing Co.
A. P. Eves	International Harvester Co.
H. L. Greene	Willys-Overland Co.
G. F. Harper	Allis-Chalmers Mfg. Co.
E. J. Janitzky	Illinois Steel Co.
J. B. Johnson	Air Service
F. C. Langenberg	Ordnance Department
F. E. McCleary	Dodge Bros.
J. A. Mathews	Crucible Steel Co. of America
C. S. Moody	C. L. Best Tractor Co.
J. H. Nelson	Wyman-Gordon Co.
G. L. Norris	Vanadium Corporation of America
W. C. Peterson	
W. H. Phillips	R. D. Nuttall Co.
S. P. Rockwell	Representing American Gear Manufacturers Association
M. P. Rumney	Detroit Steel Products Co.
C. F. W. Rys	Carnegie Steel Co.
R. B. Schenck	Buick Motor Co.
M. H. Schmid	United Alloy Steel Corporation
T. H. Wickenden	International Nickel Co.
H. M. Williams	General Motors Research Corporation

ISOLATED ELECTRIC LIGHTING PLANT DIVISION

F. L. Tubbs, *Chairman*	Alamo Farm Light Co.
F. C. Barton, *Vice-Chairman*	General Electric Co.
L. F. Burger	International Harvester Co.
G. M. Gardner	Globe Electric Co.
L. W. Holt	Holt Power Light Co.
L. S. Keilholtz	Delco-Light Co.
C. E. Reddig	Western Electric Co., Inc.
H. L. Zabriskie	Diehl Mfg. Co. (Representing Electric Power Club)

LIGHTING DIVISION

C. A. Michel, *Chairman*	Guide Motor Lamp Mfg. Co.
J. H. Hunt, *Vice-Chairman*	General Motors Research Corporation
A. K. Brumbaugh	Autocar Co.
R. E. Carlson	Bureau of Standards
G. P. Doll	Thomas J. Corcoran Lamp Co.
R. N. Falge	National Lamp Works of the General Electric Co.
C. E. Godley	Edmunds & Jones Corporation
Werner Helmboldt	Department of Motor Transportation, City of Detroit
A. R. Lewellen	Chevrolet Motor Co.
W. A. McKay	Westinghouse Lamp Co.
A. R. Osborne	Denby Motor Truck Co.
L. C. Porter	Edison Lamp Works of the General Electric Co.
E. S. Preston	Chicago Electric Mfg. Co.
C. D. Ryder	Cincinnati Victor Co.
C. E. Salisbury	Hupp Motor Car Corporation
A. J. Scaife	White Motor Co.
B. M. Smarr	General Motors Corporation
F. W. Todd	Accessories Mfg. Co.
T. I. Walker	Providence Base Works of the General Electric Co.
C. H. Williams	Studebaker Corporation of America
E. E. Wood, Jr.	Miniature Incandescent Lamp Corporation
Ernest Wooler	Cleveland Automobile Co.

LUBRICANTS DIVISION

H. C. Mougey, *Chairman*	General Motors Research Corporation
W. E. Jominy, *Vice-Chairman*	University of Michigan
Sydney Bevin	Tide Water Oil Co.
Otto M. Burkhardt	Pierce-Arrow Motor Car Co
P. J. Dasey	Wellman-Seaver-Morgan Co.
A. B. Dawson	General Motors Corporation
A. P. Eves	International Harvester Co.
R. K. Floyd	Frank H. Floyd Co.
W. H. Herschel	Bureau of Standards
L. P. Kalb	Continental Motors Corporation
K. G. Mackenzie	Texas Co. (Also representing the American Society for Testing Materials)

C. H. Osmond	Atlantic Refining Co.
W. E. Perdew	Union Petroleum Co.
H. J. Saladin	Standard Oil Co. of Indiana
H. G. Smith	Gulf Refining Co.

MOTORBOAT DIVISION

J. W. Hussey, *Chairman*	Greenport Basin & Construction Co.
C. A. Carlson	New Jersey Motors, Inc.
Irwin Chase	Elco Works of the Electric Boat Co.
Q. B. Newman, Capt.	United States Coast Guard
Leonard Ochtman, Jr.	Joseph Van Blerck Engine Corporation
W. H. Young	Belle Isle Boat & Engine Co.

MOTORCYCLE DIVISION

C. B. Franklin, *Chairman*	Indian Motorcycle Co.
A. W. S. Herrington, *Vice-Chairman*	Office of the Quartermaster General
W. S. Harley	Harley-Davidson Motor Co.

NOMENCLATURE DIVISION

H. L. Pope, *Chairman*	Wright Aeronautical Corporation
H. R. Cobleigh, *Vice-Chairman*	National Automobile Chamber of Commerce
W. P. Culver	American Auto Parts Co. (Also representing Motor & Accessory Manufacturers' Association)
A. B. Cumner	Autocar Sales & Service Co
Clyde Jennings	*Motor Age*
Herbert Chase	*Automotive Industries*
Leonard Ochtman, Jr.	Joseph Van Blerck Engine Corporation
B. M. Smarr	General Motors Corporation
L. C. Voyles	Nordyke & Marmon Co.

NON-FERROUS METALS DIVISION

W. R. Webster, *Chairman*	Bridgeport Brass Co.
W. H. Bassett, *Vice-Chairman*	American Brass Co.
A. H. Ackerman	Ackermite Co. of America
D. L. Colwell	Stewart Mfg. Corporation
G. K. Elliott	Lunkenheimer Co.
E. S. Fretz	Light Mfg. & Foundry Co.
A. J. Hall	General Motors Corporation
Zay Jeffries	Aluminum Co. of America
H. C. Mougey	General Motors Research Corporation
W. B. Price	Scovill Mfg. Co.
T. H. Wickenden	International Nickel Co.

PARTS AND FITTINGS DIVISION

W. C. Keys, *Chairman*	Gabriel Snubber Sales & Service Co.
Clarence Carson, *Vice-Chairman*	Dodge Bros.
C. R. Alling	Underwriters' Laboratories
F. A. Bonham	Durant Motors, Inc.
A. Boor	Willys-Overland Co.
Herbert S. Jandus	C. G. Spring Co.
C. T. Myers	Consulting Engineer
W. J. Outcalt	General Motors Corporation
S. V. Norton	General Motors Truck Co.
C. W. Spicer	Spicer Mfg. Corporation
H. I. Stengel	Uppercu Cadillac Corporation
E. W. Weaver	Weaver & Kemble Co.
F. G. Whittington	Stewart-Warner Speedometer Co.

PASSENGER CAR DIVISION

R. S. Begg, *Chairman*	Jordan Motor Car Co.
L. A. Chaminade, *Vice-Chairman*	Studebaker Corporation of America
F. A. Bonham	Durant Motors, Inc.
R. C. Chesnutt	Templar Motor Car Co.
H. N. Davock	Packard Motor Car Co.
E. A. DeWaters	Buick Motor Co.
G. E. Goddard	Dodge Bros.
Benjamin Jerome	Oakland Motor Car Co.
L. M. Stellmann	H. H. Franklin Mfg. Co.

PASSENGER-CAR BODY DIVISION

G. J. Mercer, *Chairman*	Model Body Corporation
Kingston Forbes, *Vice-Chairman*	Buick Motor Co.
E. J. Bartlett	Baker R & L Co.
R. E. Brown	Beaudette Body Co.
E. J. Connelly	Wilson Body Co.
A. E. Garrels	Studebaker Corporation of America
G. E. Goddard	Dodge Bros.
E. W. Goodwin	Consulting Engineer
R. A. LaBarre	Towson Body Co.
A. J. Neerken	Hupp Motor Car Corporation
George Robinson	Durant Motors, Inc.

RADIATOR DIVISION

J. D. Harris, *Chairman*	McCord Radiator & Mfg. Co.
H. A. Higgins, *Vice-Chairman*	Long Mfg. Co.
R. A. Armstrong	Oakland Motor Car Co.
H. B. Knap	Packard Motor Car Co.
Charles Oppe	G & O Mfg. Co.
C. T. Perkins	Modine Mfg. Co.
L. P. Saunders	Harrison Radiator Corporation
Fred M. Young	Racine Radiator Co.

SCREW-THREADS DIVISION

E. H. Ehrman, *Chairman*	Standard Screw Co.
O B. Zimmerman, *Vice-Chairman*	International Harvester Co.
Earle Buckingham	Pratt & Whitney Co.
Ellwood Burdsall	Russell, Burdsall & Ward Bolt & Nut Co.
Luther Burlingame	Brown & Sharpe Mfg. Co.
G. S. Case	Lamson & Sessions Co.
K. L. Herrmann	Studebaker Corporation of America
W. R. Mitchell	National Acme Co.
W. J. Outcalt	General Motors Corporation

SPRINGS DIVISION

F. A. Whitten, *Chairman*	General Motors Truck Co.
W. E. Dunston, *Vice-Chairman*	C. G. Spring Co.
A. G. Fleming	Hudson Motor Car Co.
S. P. Hess	Detroit Steel Products Co.
W. M. Newkirk	William & Harvey Rowland, Inc.
Gustaf Peterson	Atlas Steel Corporation
A. H. Remsen	Rickenbacker Motor Co.
L. M. Stellmann	H. H. Franklin Mfg. Co.

STATIONARY ENGINE DIVISION

L. F. Burger, *Chairman*	International Harvester Co.
V. E. McMullen, *Vice-Chairman*	Hercules Corporation
W. E. Morgan	Novo Engine Co.
O. A. Powell	Cushman Motor Works
C. B. Segner	Domestic Engine & Pump Co.

STORAGE-BATTERY DIVISION

W. E. Holland, *Chairman*	Philadelphia Storage Battery Co.
W. E. Gossling, *Vice-Chairman*	Prest-O-Lite Co., Inc.
G. L. Bixby	Detroit Electric Car Co.
A. K. Brumbaugh	Autocar Co.

R. N. Chamberlain	Gould Storage Battery Co.
E. L. Clark	Commercial Truck Co.
C. T. Klug	Willard Storage Battery Co.
R. C. Mitchell	Edison Storage Battery Co.
I. M. Noble	
A. R. Lewellen	Chevrolet Motor Co.
J. L. Rupp	Westinghouse Union Battery Co.
H. E. Sundheimer	Service Motor Truck Co.
G. W. Vinal	Bureau of Standards
F. G. Wells	Pierce-Arrow Motor Car Co.
C. H. Williams	Studebaker Corporation of America

TIRE AND RIM DIVISION

J. G. Vincent, *Chairman*	Packard Motor Car Co.
B. B. Bachman	Autocar Co.
H. M. Crane	Consulting Engineer
A. J. Scaife	White Motor Co.

TRANSMISSION DIVISION

L. C. Fuller, *Chairman*	Fuller & Sons Mfg. Co.
S. O. White, *Vice-Chairman*	Warner Gear Co.
A. C. Bryan	Durston Gear Corporation
W. E. England	F. B. Stearns Co.
D. E. Gamble	Borg & Beck Co.
A. A. Gloetzner	Covert Gear Co., Inc.
B. A. Gramm	Gramm-Bernstein Motor Truck Co.
G. S. Hendrie	Detroit Gear & Machine Co.
W. M. Petty	Service Motors, Inc.
H. W. Sweet	Brown-Lipe Gear Co.
C. E. Swenson	Mechanics Machine Co.
P. L. Tenney	Muncie Products Division of the General Motors Corporation

TRUCK DIVISION

A. J. Scaife, *Chairman*	White Motor Co.
J. R. Coleman, *Vice-Chairman*	
A. K. Brumbaugh	Autocar Co.
H. E. Derr	International Harvester Co.
F. W. Davis	Consulting Engineer
J. C. Haggart, Jr.	Republic Motor Truck Co.
A. W. S. Herrington	Office of the Quartermaster General
M. C. Horine	International Motor Co.
G. B. Ingersoll	Federal Motor Truck Co.
H. B. Knap	Packard Motor Car Co.
J. A. Kraus	Garford Motor Truck Co.
W. M. Petty	Service Motors, Inc.
C. B. Veal	Consulting Engineer
F. A. Whitten	General Motors Truck Co.

INTERNATIONAL MARKET FOR MANUFACTURES

THE commerce and industry of the world are undergoing a reorganization only a little less fundamental in character than that which occurred, somewhat more than a century ago, at the beginning of the development of modern manufacturing methods. This great change is the international diffusion of the knowledge of the latest technical processes and the distribution of the best mechanical equipment into every country.

The competitive advantages of special knowledge of processes and of superior equipment, together with the presence of a skilled labor force, only a little while ago possessed by Western Europe and the United States, are vanishing. It is no longer economic to haul heavy raw materials and foods thousands of miles to pay for manufactures that can be made where they are to be consumed. The nineteenth century was characterized by a mechanical advance not before paralleled in human history. The present century will witness the industrialization of the world, which is gradually returning to the condition of local self-sufficiency that the coming factory system temporarily disturbed.

The development of modern industry in Europe gradually destroyed a large part of the local industry of the civilized world. The effects on the new and sparsely settled areas were equally profound. The great competitive advantage of superior technical equipment and skill was certain to prove fleeting, and it is now being lost with a very startling rapidity.

In many lines, such as textile machinery, standardization was far advanced by 1900. The moment that stage was reached, in a very real sense the output of mechanical equipment began to be cumulative, the limit to its use being its durability. Standardization has made possible the use of replaceable parts to an extent that has added years to the working life of many types of machinery.

Already India is the foremost producer of jute fabrics and sells them all over the world. According to *The Iron Age*, exports of steel from India averaged 17,000 tons per month during the first 7 months of 1923, and Indian competition in iron and steel will probably be felt increasingly in the future. The 250 cotton mills of Brazil now have 1,650,000 spindles, 60,000 looms and 75,000 operatives, supply the domestic market with all except special grades of cloths and have at times exported a little of their product. The Brazilian shoe factories have controlled the home market for some years.

Exports of manufactures from the leading industrial countries increased rapidly from 1900 to 1914. It does not follow, however, that the demand for imports of manufactures will continue to expand indefinitely and that countries, industries or individual business organizations can safely ignore the industrial development that is taking place. Exports of manufacture from one highly industrialized country to another differ fundamentally in character from exports to a country at an early stage of industrial development. Trade between the former, unless based on an advantage of raw materials, partakes to a great extent of the character of swapping pennies. Such is much of the trade in manufactures between the United States and Canada, or between the United Kingdom and Germany. The foreign trade of the future will be based increasingly on physical advantages that in their nature are permanent in character.—E. N. Miller in *Commerce Monthly*.

JANUARY COUNCIL MEETINGS

THE meeting of the Council held in New York City on Jan. 10 was attended by President Alden, First Vice-President Crane, Vice-Presidents Masury, Ware and Warner; Past-President Bachman, Councilors Chryst, Gurney and Scott; Treasurer Whittelsey and E. A. Johnston. J. H. Hunt, H. L. Pope and M. P. Rumney, nominees for the 1924 Council, were also present.

The financial statement as of Dec. 31, 1923, showed a net balance of assets over liabilities of $146,578.37, this being $24,561.03 more than the corresponding figure on the same day of 1922. The net revenue of the Society for the first 3 months of the current fiscal year amounted to $56,937.58. The operating expense during the same period was $50,944.71.

Sixty-four applications for individual membership were approved. The following transfers in grade of membership were made: From Associate to Member, A. D. Gardner, Charles L. Carpenter, H. O. K. Meister, R. F. Buckley and R. E. Slater; Junior to Member, S. W. Colvard, Whitley B. Moore and L. G. Tinkler; Junior to Associate, W. Griffin King and Harry E. Radack.

It was reported that during the year 1923, 748 applications for membership, including student enrollment, had been received, as compared with 835 applications received during the year 1922.

C. N. Dawe was appointed to serve on the Sectional Committee on the Numbering of Steel.

The 1923 Council held the last session of its administration on Jan. 22, at Detroit, the following being present: President Alden, First Vice-President Crane, Vice-President Scarratt, Councilors Scott and Scaife, Treasurer Whittelsey, Past-President Bachman and E. A. Johnston. J. H. Hunt, J. F. Max Patitz, H. L. Pope and W. R. Strickland, nominees for the 1924 Council, were also present.

Amendment of By-Law 30 was approved, so that it shall read as follows:

> The Secretary of the Society shall be the Secretary of the Council. The Secretary shall, under the supervision of the Finance Committee, have charge of the books of account of the Society; shall make and collect all bills against members or others; shall have charge of all bills against the Society, and shall keep an account of the same, and present to the Finance Committee for its information, statements of expenditures during each calendar month, audited by a competent public accountant.
>
> All funds received by any person for the Society shall be delivered to the Secretary, who shall immediately enter them in the books of account, and deposit such funds as he receives to the credit of the Society in a bank to be designated by the Council.

Seven applications for individual membership were approved. The following transfers in grade of membership were made: From Junior to Member, C. J. Bock and L. E. Blum, Jr.

Chairman Johnston, of the Standards Committee, reported in detail the action taken by that committee on the same day with regard to the proposals of 12 of its Divisions as set forth elsewhere in this issue of THE JOURNAL.

ORGANIZATION SESSION OF 1924 COUNCIL

The organization session of the 1924 Council was held in Detroit on Jan. 23 and was attended by President Crane, First Vice-President Johnston, Vice-Presidents Patitz, Strickland and Pope, Councilors Brumbaugh, Chryst, Hunt, Scaife and Rumney and Treasurer Whittelsey.

President Crane announced the personnel of the 1924 Administrative Committees as follows:

CONSTITUTION COMMITTEE

W. A. Brush, *Chairman*

A. L. Riker | A. J. Scaife

FINANCE COMMITTEE

H. M. Swetland, *Chairman*

H. W. Alden | E. S. Jordan
A. J. Brosseau | C. B. Whittelsey

HOUSE COMMITTEE

L. D. Gardner, *Chairman*

E. Buckingham | L. R. Smith
F. W. Caldwell | C. Harold Wills

MEETINGS COMMITTEE

T. J. Lítle, *Chairman*

A. C. Bergmann | T. Milton
W. A. Chryst | H. L. Pope
K. L. Herrmann | M. P. Rumney
F. C. Horner | R. E. Wilson

MEMBERSHIP COMMITTEE

W. R. Strickland, *Chairman*

G. T. Briggs | A. F. Masury
L. C. Freeman | E. Wooler

PUBLICATION COMMITTEE

E. P. Warner, *Chairman*

C. P. Grimes | F. C. Mock
W. S. James | A. L. Nelson

SECTIONS COMMITTEE

J. H. Hunt, *Chairman*

John Younger, *Vice-Chairman*

J. A. Anglada | R. E. Northway
F. F. Chandler | Phil N. Overman
A. W. S. Herrington | H. W. Slauson
H. O. K. Meister | J. W. White
George L. McCain

The names of the members who will serve this year as Chairmen and Vice-Chairmen of the Standards Committee and its Divisions were reported. These are listed in this issue of THE JOURNAL, as well as those named by the Council for service on the various Divisions.

Discussion was had as to the program of meetings to be held during 1924.

The next meeting of the Council will be held in New York City early in March.

MEETINGS OF THE SOCIETY

THE MOTORBOAT MEETING

Standards, Engine Requirements and the Proposed Coast-Guard Fleet Discussed

Coincident with the progress of the Motorboat Show in New York City, the Motorboat Meeting of the Society was held Jan. 9, at the Hotel Commodore and was followed by a get-together luncheon in which nearly 100 members and guests participated. Walter C. Ware, president and general manager of the Fay & Bowen Engine Co., Geneva, N. Y., was chairman. In his opening remarks he called attention to the fact that the standardization work as regards marine application is just starting and that it may be several years before satisfactory results can be obtained. It is only as the builders change their own designs and then adopt the standards that have been decided upon by representative members of the industry that the desired degree of standardization can be obtained.

Following his introduction by the chairman, George F. Crouch, naval architect, New York City, presented his paper entitled Engines for Motorboats. He said that his purpose in presenting these comments is to convey the idea that harmony of effort toward perfection of the product and a certain mutual understanding of the problems of engine and boat building and naval architecture is advocated. The viewpoint is that of a naval architect concerned with the installation of marine engines in the hull of a vessel and with giving an owner what he demands as to speed, reliability and accommodations. But Mr. Crouch finds that the problem today is that of working-out a 1924 engine-installation with a 1904 engine-control arrangement.

Remote control of the spark, the throttle and the reverse gear were discussed by Mr. Crouch, and he made suggestions for their improvement. The architect's desire is to place the engine as low in the hull as possible, so as to reduce the angle of the propeller-shaft. Obstacles that hinder such accomplishment were mentioned and comments made concerning flywheel enclosure. He hopes for a reliable engine that will have an efficient and reliable reduction-gear as an integral part of the engine.

He presented minor details relating to reliable and compact installation for consideration and treated the subject of suitable accessories briefly. His subject matter applies mainly to highly powered cruisers, and to boats of the runabout type.

In the discussion that followed, Walter S. Peper asked whether flywheels should be placed forward or against the reversing gear. Mr. Crouch's reply was that flywheels may be aft in slow-speed runabouts, but not in those of the 40-m.p.h. class. A further question by Mr. Peper, whether the crankcase should be parted on the center-line of the crankshaft, elicited a reply from Mr. Crouch that the crankcase can be parted anywhere but it must have supporting flanges near the centerline of the shaft and there must be no flange support below it. Chairman Ware then gave an instance within his experience, a case in which projections of 1¾ in. below the center-line had necessitated a change in an entire model. The point was raised by C. A. Criqui, of the Sterling Engine Co., Buffalo, N. Y., that the maximum amount of clearance under the engine at the after part must be provided. H. L. Pope, works manager of the Wright Aeronautical Corporation, Paterson, N. J., stated his belief that most of the trouble is due to accessories. He suggested a meeting of naval architects, engine builders and accessory manufacturers with a view toward agreement upon some broad standard specifications for accessories. Water-pump trouble was cited, and the suggestion made to use only shafts that are of rustless material. Further, that the experience of aeronautic engineers be applied so far as possible in an effort to obviate trouble.

Standardization of the Engine Bed

In addressing the meeting with regard to the above subject, C. A. Carlson of New Jersey Motors, Inc., Keyport, N. J., stated that a recent investigation among manufacturers and builders had developed the fact that 96 different widths of engine bed are in use and that 72 different engine widths also are in use. He thought also that within the past 2 months cooperation among the interested parties has improved greatly and that shortly a specification for motorboat engine-bed standardization will be issued. He remarked upon the fact that it is not easy to standardize anything. He said also that the owner of a small boat cannot afford to spend much money. There is extensive cooperation between engine and boat builders now, and he stated his belief that good results will be evident within a year. The present plan is to standardize engine beds first, then to submit the recommended specifications to all interested parties for their approval and comment.

Following Mr. Carlson's remarks, Chairman Ware said that the Society has had committees that have been working on this subject and that they have adopted steel specifications and specifications for controls, for screw-threads, for bolts, nuts and the like and that these specifications are in use at present. He stated that the Fay & Bowen Co. uses the S. A. E. Standard Specifications whenever it is possible to do so. He mentioned also that boat builders and engine agencies have requested specifications for standardized couplings.

Leonard Ochtman, Jr., of the Joseph Van Blerck Engine Corporation, New York City, remarked that the Society already had standardized couplings some years ago but that these had not been used for the reason that they were not wholly suitable. He recommended revision to make them more adaptable. In his opinion it is preferable to use a taper on the front end of a propeller-shaft and to set-up the coupling on this taper with a nut. He stated that trouble comes in the installation and asked why a new type of coupling to take the place of the taper coupling should not be developed.

The question was raised that if the taper be used on the front end of a coupling, why should it not be used on the rear? To this Mr. Ochtman replied that the shaft often needs to be cut to fit the boat when it comes to installation. In this connection Chairman Ware remarked that the engine builder does not furnish the propeller-shaft. In response to the suggestion by H. L. Brownback that an investigation be made of the standard specifications which the United States Government now has with regard to engine beds as applied to airplane practice and that these be studied with a view to application in the interests of marine work, Mr. Carlson stated that these data apply only to engines of very high power and of the type that is not applicable to marine work. Supplementing this remark Chairman Ware said that 86 per cent of the total number of engines built for marine work, such as were being discussed, were under 60 hp.

L. C. Hill, assistant general manager of the Society, emphasized the fact that in considering standardization in the motorboat field it is not expected that patterns are to be thrown out of the window. He gave instances in which draftsmen have designed small parts such as nuts and bolts

rather than to investigate and incorporate in their design standard nuts and bolts for which specifications have been issued by the Society and are in practical use. Referring to the S. A. E. HANDBOOK, Mr. Hill said that the book is full of standards that already have been adopted by the marine division and that can be used just as well as not.

Mr. Criqui then said that it has been customary with his organization, in laying-out a new engine, to have before the designer as many engine outlines as could be obtained, the idea being to try to make the new design fit in the place of all the other designs of engine to the advantage of the company. He suggested that the boat builders can assist the engine builders if they keep the fore-and-aft stringers far enough apart so that the engine bed can be built in between them. His plea is for a standard distance to be set as a basis for a new layout. He wished to have the stringers that run fore-and-aft kept far enough apart so as to give sufficient space to bolt-in the foundation.

Mr. Carlson said in reply that three widths of stringers will be suggested and that these are necessary because of different horsepowers, different widths of engine bed and the like; afterward, a final standard will be adopted. Mr. Crouch said that the bed itself is best supported when it is bolted through the side stringers. Also that to put blocks of fill-in pieces between the engine bed and the stringers is bad practice. He also called attention to the fact that wood fastened together with metal fasteners is likely to be damaged because the metal fastenings are so much stronger than the wood. Unless there is a bearing of wood to wood, parts will work loose under vibration and stress due to the crushing of the fastening in the wood.

Chairman Ware then asked what it was thought the Society had best concentrate its efforts upon first with regard to standardization. In reply H. L. Brownback remarked that there seemed to be no standard installation of exhaust pipes. He recommended that the engine and the boat builders formulate some standard method for holding the exhaust piping in place and some standard sizes of exhaust piping. Referring to reverse-gear standardization, Chairman Ware stated that several of the principal reverse-gear manufacturers have cooperated to such an extent that now their gears can be installed interchangeably in the same oil-tight case.

Sidney R. Dresser called attention to the great importance of having proper specifications for ignition wiring. He said that, even with a good battery, first-class ignition systems and an excellent starter, if the wire had been improperly specified, an insufficient amount of current might be transmitted to the starter to make the engine function properly. He said that he had made a personal investigation of starting cables made by 19 different manufacturers and had found that 21 different standards or specifications of wires were in use. In response to an inquiry from Mr. Dresser, the chief engineer in one of these plants said that he had given the subject of wiring specifications very little thought. Mr. Dresser knows of very few boats that are wired properly. He recommends that adequate standardization of the wire for ignition systems be made. He believes that the trouble mentioned as having been caused largely by the accessories will be practically eliminated.

The Proposed Coast-Guard Fleet

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CAPT. Q. B. NEWMAN

Capt. Quincy B. Newman, chief engineer of the United States Coast Guard, gave a very interesting description of the plans of the Government in reference to the proposed Coast-Guard fleet. He spoke for Admiral Reynolds, who was unable to be present. The Coast Guard was established 133 years ago to suppress what Captain Newman termed "the illegal importation of merchandise." In the course of time smuggling decreased, but the Government recognized the necessity for some sort of force to prevent smuggling and therefore maintained what was known as the Revenue Cutter Service, now the Coast Guard. In the

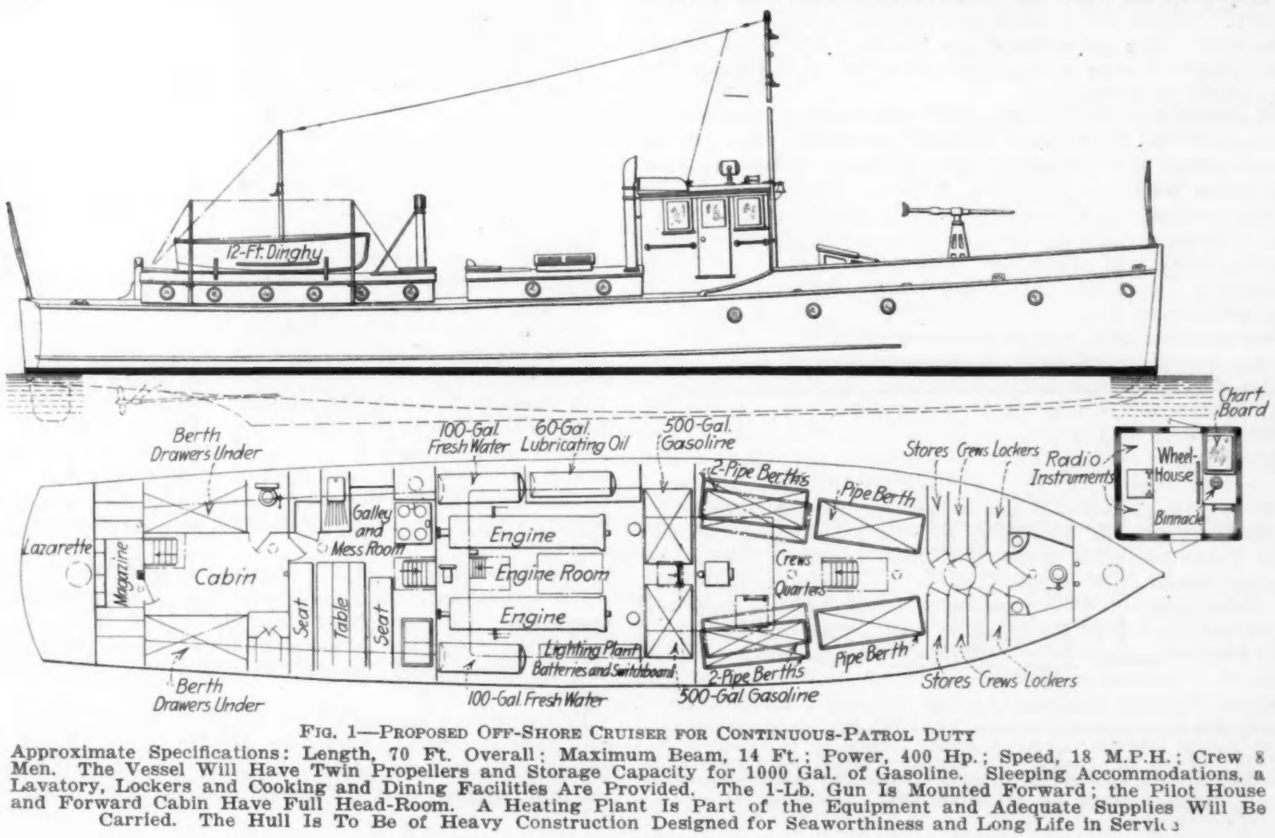


FIG. 1—PROPOSED OFF-SHORE CRUISER FOR CONTINUOUS-PATROL DUTY

Approximate Specifications: Length, 70 Ft. Overall; Maximum Beam, 14 Ft.; Power, 400 Hp.; Speed, 18 M.P.H.; Crew 8 Men. The Vessel Will Have Twin Propellers and Storage Capacity for 1000 Gal. of Gasoline. Sleeping Accommodations, a Lavatory, Lockers and Cooking and Dining Facilities Are Provided. The 1-Lb. Gun Is Mounted Forward; the Pilot House and Forward Cabin Have Full Head-Room. A Heating Plant Is Part of the Equipment and Adequate Supplies Will Be Carried. The Hull Is To Be of Heavy Construction Designed for Seaworthiness and Long Life in Service

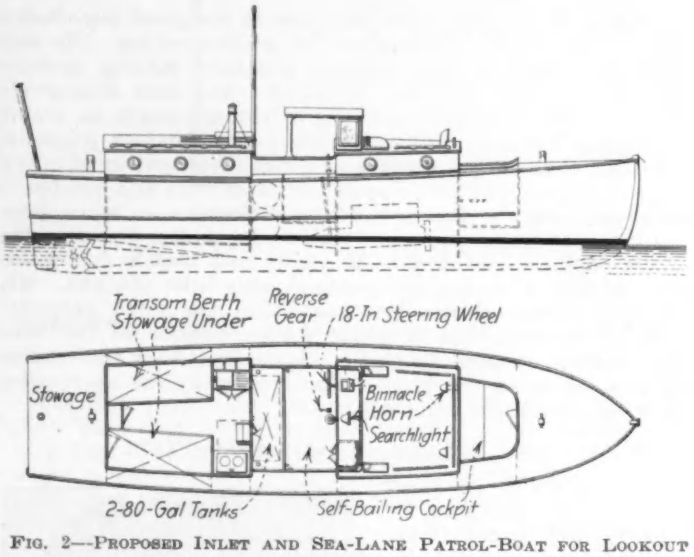


FIG. 2—PROPOSED INLET AND SEA-LANE PATROL-BOAT FOR LOOKOUT SERVICE

Apprixmate Specifications: Length, 36 Ft. Overall; Single Propeller; Power 150 to 180 Hp.; Crew, 3 Men. The Boat Is Not Designed for Continuous Patrol in the Open Sea, but for Occupying Lookout Positions in Nautical Thoroughfares and Inlets. A Semi Pilot-House Will Afford Protection for the Man at the Wheel, a Small Cabin Aft Will Have Folding Bunks and a Small Galley-Range and a Heating Plant Will Be Included in the Equipment. A Small Portable Searchlight, Pistols and Rifles Will Be Carried. Possibly, a Machine-Gun May Be Added

interim and until recently, the work of the Coast Guard has been largely in the assisting of distressed mariners. The boats in use were built largely for seaworthiness, and hence their speed was moderate. In the Life-Saving Service, the primary object was safety.

When it was found that smuggling had not become a lost art, the discovery was made that, with regard to equipment, the Coast Guard had unsuitable tools. Following the recent determination of the Administration that this illegal traffic must be suppressed, the authorities turned to the Coast Guard as the agency through which this condition will be caused to cease. In his annual message to Congress, the President stated that the Coast Guard must be enlarged greatly. Therefore, a definite program was laid out and submitted to the Director of the Budget, who is to submit it to Congress with recommendations for an adequate appropriation of funds.

To understand the problem, it is necessary to consider the purpose of the enemy and then to determine what can be done to defeat that purpose. The sole object of the smuggler is to make money. Therefore, it is necessary to make his

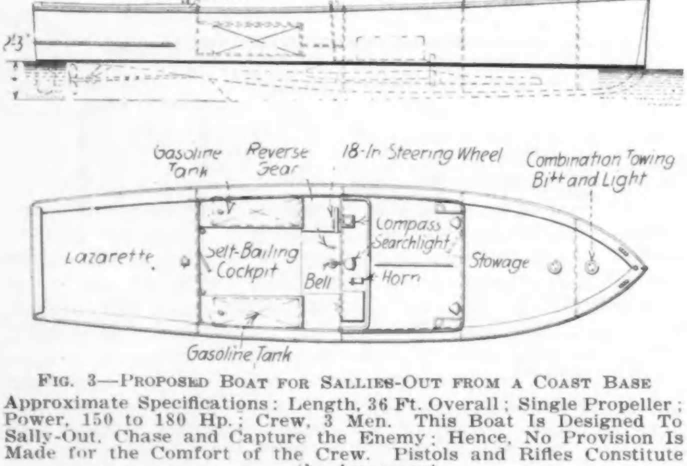


FIG. 3—PROPOSED BOAT FOR SALLIES-OUT FROM A COAST BASE

Approximate Specifications: Length, 36 Ft. Overall; Single Propeller; Power, 150 to 180 Hp.; Crew, 3 Men. This Boat Is Designed To Sally-Out, Chase and Capture the Enemy; Hence, No Provision Is Made for the Comfort of the Crew. Pistols and Rifles Constitute the Armament

business less profitable. If 90 per cent of the traffic were stopped, the remaining 10 per cent would not pay because of the excessive overhead charges. The difficulty is that the Coast Guard is blockading what is apparently a friendly coast. When at war, the Navy blockades the enemy's country; consequently, it must remain at sea and try to head-off the blockade runner before he reaches the coast. But in this case the Coast Guard is on the shore of the enemy and the enemy must come to it. If the enemy lands cargo in bulk, he must come through inlets to the coast. It might be possible to anchor a scow equipped with a gun in all inlets and stop importation in that way. However, that is not the best way. If fast boats were designed and placed in service for the Coast Guard's use, they would be superseded by faster boats. The present need is for fast boats that are armed, because it is necessary to get within gun range of the enemy. In this connection Captain Newman emphasizes that the right of search is necessary and should be complied with without any resistance.

PROPOSED TYPES OF BOAT

Plans were shown illustrating the proposed types of boat that are desirable for Coast-Guard service. The first of these is shown in Fig. 1; it is about 70 ft. long overall, 14-ft. maximum beam and has approximately 400 hp. It is designed to develop a speed of about 18 m.p.h. This boat is to be used for maintaining continuous patrol. Since the patrol must be on duty 24 hr. per day, 7 days per week on the lookout for the enemy, adequate attention must be paid to the carrying of sufficient provisions and providing for the daily comfort of the personnel. As elsewhere, if efficiency is expected of men, they must be reasonably comfortable while they are engaged in the performance of their duty and this is especially true on board ship. Two gasoline tanks having a total capacity of about 1000 gal. are provided. The armament includes a 1-lb. gun mounted forward. This has a penetrating capacity that will puncture the average boiler-plate around a pilot house. The entire boat is to be constructed for seaworthiness and for long life in service.

Fig. 2 shows the 36-ft. boat. It is designed for much the same sort of duty as that of the boat shown in Fig. 1, except that this vessel is not to be used off-shore. It will take a position in inlets and be on the lookout but will not maintain continuous patrol in the open sea. It will be a single-screw boat having a cabin aft and is of 170 to 180 hp., although this may be increased to 200 hp. if found profitable. The boat will have a small portable searchlight and will be armed with pistols and rifles. Possibly, a machine-gun will be included.

Fig. 3 is a 36-ft. boat similar to that shown in Fig. 2 but without any cabin protection for the crew. It is intended to make sallies out from the coast and to capture the enemy after a short run.

Saying that something is fundamentally wrong with citizens who treat as a joke the fact that ships flying foreign flags are infesting our coast for the purpose of violating not only the law of the United States but the Constitution of the United States, Captain Newman emphasized as his firm belief that, irrespective of whether a citizen is or is not a prohibitionist, that citizen should stand firmly back of the enforcement of law. The Coast Guard stands for the enforcement of law, and it is determined to see that the law is enforced. He said that if an appropriation is made available so that adequate equipment can be secured, the importation of liquor and narcotics will cease within a very short time.

Supplementing Captain Newman's address, Lieut-Com. F. A. Honeywell said that the Coast Guard bespeaks cooperation. He recognized the Motorboat Meeting as an opportunity for the accomplishing of cooperation such as the motorboat and the marine industries had never had before.

Replying to a question from N. W. Akimoff, Captain Newman said in regard to whether the Coast Guard can utilize vessels from other departments of the Government this, it is believed, applies only to vessels of 200-ft. or more overall

length and driven by steam power. He said further that it is the desire to standardize all of these boats so far as possible and also to standardize the machinery so that each class of boat will have one type of engine. In such case, the engine will be interchangeable between different boats and the personnel will also become familiarized with the one type of engine that is being used.

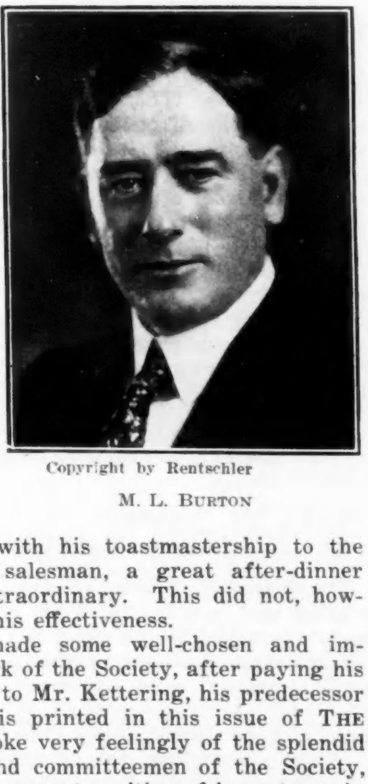
With regard to the method of procedure, Captain Newman said that the Coast Guard has decided to purchase a considerable part of the equipment for these boats direct from the manufacturers, to deliver it to the boat building yards and to accept the responsibility for the performance of the machinery and for the speed developed by the boat. All this will be stated clearly in the specifications and contracts. Under this plan the Coast Guard contemplates furnishing propelling machinery, propellers, electric-light plants, storage-batteries, pumps, blowers and the like. He said that estimates are that the situation can be met adequately with 223 of the 70-ft. boats and 100 of the 36-ft. boats. Of the latter class it is proposed to make 70 of the cabin type and 30 of the open type. These numbers were recommended after a careful examination of conditions.

In reply to a query from W. J. Parslow, Captain Newman said that the Government does not recognize a sub-contractor, and the contractor himself is responsible for the work of his sub-contractor. Further questions from Mr. Parslow brought the reply from Captain Newman that the profits of the builders will be on the hull alone. In mentioning a new form of Government contract that is proposed, Lieutenant-Commander Honeywell spoke of its being more advantageous to outside firms than previous Government contracts. He said also that, while sub-contracting is not prohibited, it is stated that the contracts as a whole cannot be assigned.

The general discussion was continued informally during the progress of the luncheon that was served immediately after the meeting.

THAT MIND OF YOURS

Good Fellowship and Intellectual Feast at the Annual Dinner of the Society



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M. L. Burton

Probably no finer address was ever made at a meeting of the Society than that of President M. L. Burton, of the University of Michigan, at the 1924 Annual Dinner of the Society in New York City last month. This address will be published in full in an early issue of The Journal.

E. S. Jordan, who was introduced by President Alden as toastmaster, was very heartily received by the members and his conduct of the speaking program was highly satisfactory. Mr. Jordan said that he had been much disconcerted by the announcement in connection with his toastmastership to the effect that he is a great salesman, a great after-dinner speaker and a humorist extraordinary. This did not, however, in any degree reduce his effectiveness.

President-Elect Crane made some well-chosen and impressive remarks on the work of the Society, after paying his respects to Mr. Jordan, and to Mr. Kettering, his predecessor as toastmaster. His talk is printed in this issue of The Journal on p. 171. He spoke very feelingly of the splendid efforts of former officers and committeemen of the Society, which have brought it to its present position of importance in the automotive industry. He entered a plea for more extensive use of the standards established by the Society. He expressed the opinion that the first great undertaking of the Research Department of the Society, that is, the fuel investigation, had been of tremendous value to the industry.

With regard to the work of the Bureau of Standards in fuel investigation and other matters of vital consequence in connection with the production and use of motor vehicles, Mr. Crane emphasized the need for Congress making appropriation in an amount adequate to enable this department of the Government service to proceed effectively. In discussing the effort of the Council to maintain a policy that will result in the Society giving the best possible service to its members, Mr. Crane said that the most effective method of handling the Sections of the Society and of fostering their relations to the parent Society constitutes the most important problem to be considered this year.

In a word, Mr. Crane summed up his opinion of the value and function of the Society by saying that no organization in the industry is so big that it can do without the Society.

Toastmaster Jordan introduced President Burton as a man possessing brains, aggressiveness and great administrative capacity.

President Burton spoke to the subject, That Mind of Yours. His theme was that quality of mind determines the success of any organization and of any one's personal life. He mentioned some rather clear understandings that ought to reflect light on the subject. The mind is something that has been in preparation through millions of years. In furthering the sympathetic feeling and understanding of his hearers, the speaker said that life has too many funny things to ever take it seriously, and moreover that it is bad enough to be a university president without being taken for one. He said that everyone, in spite of what he may think or his wife tells him, has something inside of his head that, if he would really use it and make it what it ought to be, would be one of the most startling, amazing, puzzling and mysterious things with which he ever dealt. We all have a chance to take this thing that is inside our heads and make it a little better for what the generations that are to come must have. Almost any kind of government, save a democracy, can put up with intellectual incompetence. If we are in any reasonable sense to accept our present responsibilities, we must have minds capable of walking straight up to the fundamental issues of a new civilization and solve them with clearness, decisiveness and conviction. The position in which we find ourselves is due largely to the fact that men with clear minds have thought out some of the fundamental problems of science. The mind is absolutely primary for individuals and for all as a group and for civilization as a whole.

Types of Mind

In classifying types of mind, President Burton quoted Emerson's remark to an audience: "Don't try to make another person like you, one is enough." The glory of the human race is that no two minds are alike. Many persons have remarkably receptive minds, upon which anybody can impress anything he wishes and keep it there as long as he desires. The man of independent mind has ability to weigh evidence. He is not swept off his feet by waves of emotion or passion. He is determined if possible to get at the truth but also that when facts are presented to him he shall think them through for himself and make his own interpretation of them.

President Burton defined a conservative as a man who believes that in the past is something that it worthwhile. He believes in the stability of society and that every time a new person is born he does not have to start all over again. This type of mind makes it possible to accomplish what we do through the ages. The chief defect of a conservative is that he is inclined to confuse truth with time. He feels that a thing is true because it is old or false because it is new, forgetting that truth knows no time distinctions. The thing is true because it accords with the standards of reason and experience.

The radical is not unduly concerned about the past. He believes in progress. The difficulty with the radical is that

he confuses truth with terms. He forgets the profoundest lesson of the history of thought, namely, that truth must accord with an objective outside of and beyond our little selves. Whether a mind be conservative or radical, it should face honestly the stern unescapable realities of an outer universe. In American education there has been failure to understand adequately that in every human mind there are undreamed possibilities and capacities. The top 5 per cent in every class can do from 10 to 15 times as much work as the lowest 5 per cent can do in the same time. Effort is being made to adjust that situation in the universities. America must have and in every organization there must be a place for the mind that can think and will go in directions that have not been dreamed of. We must believe in the creative mind. If we do not keep up our research, we are not worthy of the resources we enjoy. The process of education begins when something gets to work inside of your own head; that is the only way you will ever get anywhere.

The ideal type of mind is the active mind. It is possible for a man to get the kind of mind he ought to have, if he wants it. Brains plus character make success.

ELECTION OF OFFICERS FOR 1924

Number of Ballots Cast Greater Than in Any Previous Election

The result of the election for officers to serve this year, beginning with the close of the Annual Meeting of the Society held in Detroit last month, was announced at the 1924 Dinner. The tellers of election were W. E. Kemp, A. M. Wolf and R. E. Plimpton.

It was reported that 969 ballots had been cast, 15 of these being void. The result of the election, with a few scattering votes, was as follows:

President	
H. M. Crane	953
First Vice-President	
E. A. Johnston	951
Second Vice-President Representing Motor-Car Engineering	
W. R. Strickland	954
Second Vice-President Representing Tractor Engineering	
J. F. Max Patitz	951
Second Vice-President Representing Aviation Engineering	
H. L. Pope	951
Second Vice-President Representing Marine Engineering	
W. C. Ware	953
Second Vice-President Representing Stationary Internal-Combustion Engineering	
T. B. Fordham	953
For Members of the Council (To serve for 2 years)	
J. H. Hunt	954
A. K. Brumbaugh	954
M. P. Rumney	953
For Treasurer	
C. B. Whittelsey	954

In addition to those named above, the following members of the 1923 Council will serve as members of the Council for this administrative year: Past-President Alden and Councilors Chryst, Gurney and Scaife. The Council is constituted of 15 voting members.

THE ANNUAL MEETING

Nearly a Thousand in Attendance at Detroit

Eclipsing all attendance records set by past meetings of the Society, the Annual Meeting in Detroit may be recorded as a distinct success. Nearly 1000 men registered during the 4-day meeting period. Practically all sections of the Country and all branches of the industry were represented. The total registration was not, however, the most noteworthy feature, but rather the attendance at the technical sessions, this being as high as 500 in some cases.

Judging from the interest shown and the tone of the discussion at the Brake Session, it is safe to say that four-wheel brakes still hold the center of the automotive engineering stage. General difference of opinion is still evident on the finer points of brake design. Whether internal or external brakes are best suited to the requirements of four-wheel systems is a matter of debate. Designers do not agree as to the need for releasing the brake on the outer front-wheel when turning a corner.

Despite the fact that fuel, carburetion and detonation have been major topics of several National meetings of the Society, no relaxation of interest in the current papers on these subjects was noticed. It is apparent that designers are still in search of better fuel economy and more efficient combustion.

Attendance at the production sessions did not come up to expectations, although the papers were of an unusually high standard. It is possible that the production men were not fully cognizant of the fine program or that they had the erroneous impression that the sessions were arranged primarily to cover designing problems. At any rate, the discussions were productive of much valuable information and men in the manufacturing end of the business will find the papers and reports of considerable interest to them.

Fascinating demonstrations were made in some of the technical sessions. Leather-testing machines, leather-patching devices and methods of testing automobile upholstering fabrics were shown and explained to those who attended the Body Sessions. Thomas Midgley, Jr., gave a vivid demonstration of the effect anti-knock fuels have on combustion by running an engine fitted with an optical pyrometer. A quartz insert in the cylinder wall enabled the members to see the changes in color of the flame with variations in the character of the fuel and in the mixture-ratio.

A complete illustrated news report of the Annual Meeting is given on the following pages. Most of the papers read at the meeting are reproduced in full in this issue of THE JOURNAL. Written discussion of these papers is encouraged and will be published with the formal report of the oral discussion, if forwarded to the offices of the Society before Feb. 25.

BODY ENGINEERING SESSIONS

Papers on Enameled Bodies, Glue, Plating and Trimming Materials Read at Detroit

Pre-enameled bodies, casein glue, more durable nickel-plating and deleterious effects of drying-oven temperatures were the subjects discussed at the first of the two Body Engineering Sessions at the Annual Meeting in Detroit. Otto Graebner, chief engineer of the J. C. Widman Body Co., described progressive steps in the construction of a new type of body developed by that company. In this construction the wood framework is conventional but the advantages of baked enamel finish are made available by enameling and baking the individual metal panels before assembling them to

L. N. Ericksen K. L. Herrmann H. T. Strong Otto Graebner
SOME OF THE SPEAKERS AT THE BODY SESSIONS

the wood frame.[1] Mr. Graebner said that the most difficult problem encountered in the production of this new body is the proper preparation of the metal panels for enameling. He submitted the following comments on this matter.

How Individual Panels Are Enameled

Hood and fender stock is used throughout for the panels and the metal must be free from pores and defects. In case waves and wrinkles are present, the panels are power-hammered and buffed with emery wheels. In finishing panels, emery wheels of No. 100 emery are used first and the finishing is done with a No. 120 emery wheel. Files are never used. All panels are inspected over fixtures for size and finish, after which they are ready to be cleaned for enameling, using the following method:

(1) To remove oil and grease, the metal is dipped into a solution called Wyandotte Cleaner and allowed to remain for from 3 to 10 min., depending upon the condition of the metal
(2) Dip in cold water
(3) Put into a Deoxolyte solution, using 1 part of Deoxolyte to 15 parts of water. To clean new metal, leave in this solution for about 2 min. only. If the metal is rusty, leave it in about 5 min.
(4) Dip into cold water again
(5) Dip into hot water
(6) Wipe with rags dipped in clean cold water and then wipe dry with clean rags. After this the stampings are taken to the burn-off oven, going through 600-deg. heat to clean and dry them. They are then wiped with clean rags and blown off with compressed air, and after another inspection they are ready for enameling

All enameling is done in the conveyor-type oven, moving at the rate of 8 in. per min. to allow time for the excess enamel to drip off and enamel the panels properly. The ovens are kept at a temperature of 450 deg. fahr. After coming out of the second oven the small panels are inspected as to finish and placed in racks ready for assembling of the body. Large panels are rubbed with pumice-stone and cleaned very carefully after the second coat has been applied and are then given a third coat, after which they are ready for inspection. Passing inspection they are put into crates and are ready for assembling of the body.

Manufacture and Attachment of Panels

Many interesting points about the pre-enameled body were brought out by the questions following Mr. Graebner's paper. No panels are flanged on the body, although the cowl panel is bent slightly at the flange when it is fitted to the body. This slight bending, about ⅛-in. on a ¾-in. flange, does not crack the enamel. The panels are not all formed to fit the body frame exactly; some springing effect that puts a tension into the panel as it is applied is present. This has to be done in some cases such as the door panels to avoid hollow spots in the applied panel. Nail-holes are pierced in most of panels after the stamping operation, although some are pierced in the stamping operation proper. Relatively little spot-welding is used, this being limited principally to the cowl-panel assembly. The rear-seat panel is made of three parts with joints at the rear quarters which are covered with applied moldings. This makes it possible to take up all variation in the panels or the wood structure at the joints, which are concealed by the applied moldings. Mr. Graebner doubted whether it would be practicable to use a one-piece rear-seat panel since no means of compensating for variations would be provided and this would require extreme accuracy in the panels and the wood framing.

George Goddard said that care must be taken in buffing panels with emery-wheels because the operators sometimes press too hard against the panels, causing them to heat and distort. Buffing operations have been eliminated on Dodge bodies except on the cowl and the upper edge of the rear-seat panel. Mr. Graebner has encountered similar difficulty and said that the minimum amount of finishing is done with the buffing-wheels for this reason.

All the large panels of the Widman body are given three coats of enamel baked at a temperature of 450 deg. fahr. Color enamels have not been tried. All enamel coats are applied by dipping and both sides of the panels are coated. The enameled panels are carefully protected by felt-lined racks and felt pads are placed between the panels from the time they are baked until they reach the assembly-room. A felt pad is provided also over the body itself so that workmen cannot scratch the panels if they lean or rub against them while working on the trimming or other operations.

Three-quarter inch No. 16 rustproofed nails are used to attach the panels to the wood frame; the moldings that cover the joints are bolted on. Screws are not used in attaching any of the metal panels. Cotton wadding is put between the panels and the strainers, but it is not used under the nailed edges. Panels damaged during or after assembly are removed from the body and replaced. Very small defects are sometimes touched-up with air-dry enamel, but never on the large panels.

CASEIN GLUE FOR BODY ASSEMBLY

W. A. Henderson's paper on casein glues for body assembly is printed in full in this issue of THE JOURNAL on p. 182. Some of the points raised in the discussion of it are reported in the following paragraphs.

Casein glue can be baked at a temperature of 420 deg.

[1] See *Automotive Industries*, Oct. 4, 1923, p. 681.

fahr. without ill effect, provided it is allowed to stand for 24 hr. after being removed from the oven. Parts glued with casein glue are left in the clamps about the same length of time as those assembled with hide glues. An hour and a half to 2 hr. will insure sufficient adhesiveness for handling. Casein glues as first developed had a tendency to dull cutting-tools too rapidly. This has been overcome by decreasing the lime-content of the glue. Mr. Henderson said that this had not affected the physical properties of the glue. The new casein-glue powder sells for 20 cents per lb. and 1 lb. of the glue powder is mixed with 2 lb. of water to prepare the glue used in body construction.

R. A. LaBarre, chief engineer of the Towson Body Co., said that he had experimented with the new casein glues, found them unusually satisfactory from the standpoint of adhesiveness and moisture resistance and had not encountered any of the previous trouble from dulling of woodworking tools.

NEW NICKEL-PLATING PROCESS DESCRIBED

Rust resistance of nickel-plated steel formed the topic of a paper read by Prof. E. M. Baker as the concluding feature of the first Body Engineering Session. Professor Baker's paper is printed in full in this issue of THE JOURNAL, starting on p. 127. It was evident from the discussion that all body engineers are having difficulty in securing a durable nickel-plated finish on body parts, particularly those on the exterior of the car.

FORCED DRYING PRESENTS PROBLEMS

Relation of Moisture-Content, Humidity and Oven Temperatures Must Be Balanced

Deleterious effects of high-temperature ovens on elm and other inexpensive woods present a problem that the body-builder wants solved, according to W. H. Jones, chief engineer of the C. R. Wilson Body Co., who opened a discussion of the subject at one of the Body Engineering Sessions in Detroit. Many companies have installed accelerated-drying systems, painting conveyor-systems and other expensive equipment only to find that the use of the higher drying-temperatures has forced them to abandon the use of elm and maple and return to the more expensive ash, thus offsetting a considerable part of the saving accomplished by the more rapid painting process. Elm is a satisfactory lumber for body use, but Mr. Jones has found that it cannot withstand the temperatures encountered in the modern drying-oven.

Paint manufacturers recommend a drying temperature of 150 deg. fahr., with a humidity of 28 per cent. The Forest Products Laboratory says that lumber entering ovens kept at this temperature should have a moisture-content of but 4 per cent, a condition that is hard to achieve with 28-per cent humidity. Increasing the moisture-content to 7 per cent means increasing the humidity to 48 per cent; this is a handicap since the greater humidity increases the paint-drying time, cuts down the production and increases the floor-space required. Protective heat-resistant primers have helped somewhat in solving the problem of using elm and maple, but Mr. Jones expressed the hope that still further steps will be taken so that the cheaper woods can be used without trouble.

R. A. L.aBarre, chief engineer of the Towson Body Co., encountered trouble with door-pillars checking after passing through the drying ovens, and has experimented with different humidities in the ovens in the hope of correcting the trouble. The Towson Body Co's. lumber kilns are operated to dry the lumber down to about 5 per cent moisture-content, the heat being raised from about 120 deg. fahr. with 100-per cent relative humidity to about 170 deg. with a relative humidity of about 40 per cent. It was believed that if the same relative humidity were maintained in the paint ovens as in the lumber kilns, the checking would be reduced. The rough-stuff ovens were being operated at approximately 130 deg. on the dry bulb and the wet bulbs were stepped-up from 97 to 103 deg., but it was found that the rough-stuff was not properly dried for the rubbing operation. After further experimenting, 130 deg. on the dry bulb and 100 deg. on the wet bulb were set as the standard for the rough-stuff ovens. This is still too low to give the correct results with the lumber but Mr. LaBarre believes it is as near the desired point as can be reached without affecting the paint.

Conditions are even worse for varnish drying since these ovens cannot be run above 120 deg. fahr. on the dry bulb and 90 deg. on the wet bulb, or a relative humidity of about 31, which is 9 deg. lower than that when the wood leaves the dry kiln. Lumber taken from the kiln soon gathers additional moisture, so that conditions are not as bad as they may seem. Mr. LaBarre has encountered trouble with loosening of screws and bolts after passing through the drying ovens and has found it necessary to add an operation of hand-tightening.

The Towson Body Co. uses the following practice in its dry kilns:

First Week—Start at 120 deg. fahr.—Relative humidity 100.

Second Week—Raise temperature to 135 deg.—Relative humidity 79.

Third Week—Raise temperature to 150 deg.—Relative humidity 57.

Fourth Week—Raise temperature to 170 deg.—Relative humidity 40.

This dries the lumber to about 5-per cent moisture-content and practically no trouble is experienced with case-hardened or honey-combed effects.

W. R. Palmer, of the A. S. Nichols Co., spoke briefly as a representative of one of the large manufacturers of drying systems. He stated that in his opinion most of the troubles would be eliminated if the body lumber were dried to a little lower percentage of moisture than it will equalize in the drier rooms or ovens.

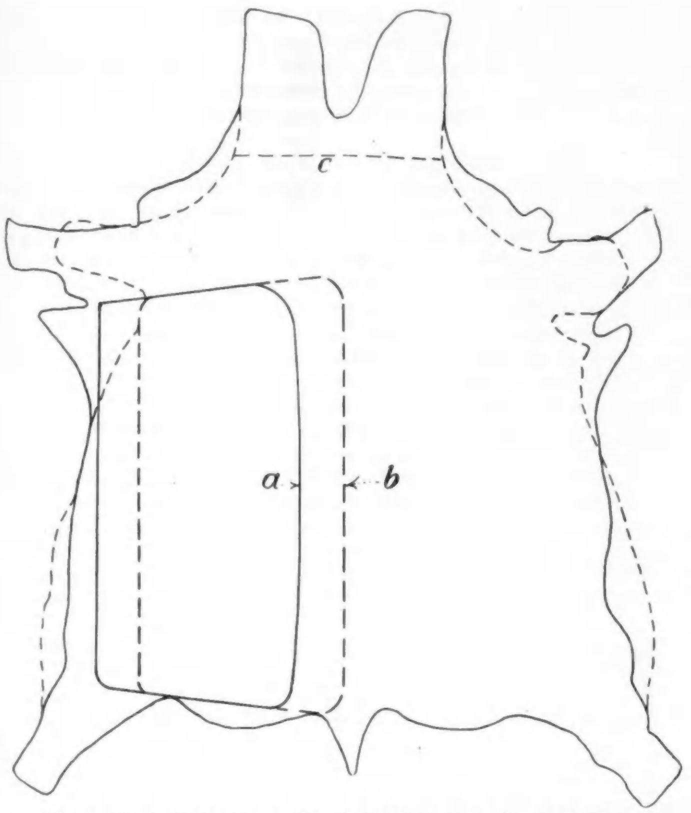
SAVING OF $2,000,000 PREDICTED

Use of Patched Hides in Body Upholstery Made Possible by New Method

A saving of $2,000,000 per annum by the passenger-car builders as a result of standardization of upholstery leather was predicted by K. L. Herrmann at the Body Engineering Session on Wednesday afternoon. Mr. Herrmann's paper on Automobile Upholstery Leather was in general a review of the work of the Subdivision on Upholstery Leather, of which Mr. Herrmann is chairman. The Subdivision had presented definite leather specifications for adoption at the Standards Committee Meeting on Tuesday. These specifications were printed on p. 44 of the January, 1924, issue of THE JOURNAL.

The saving predicted will be due primarily to a method of patching proposed by Mr. Herrmann which makes it possible to use hides classified at the present time as seconds owing to their having five or more grub-holes, such hides bringing a much lower price than full-grain snuffed leather. Under present tanning practice these holes are patched to keep the coating solution away from the reverse side, but with few exceptions such patches cannot be used in finished upholstery. Mr. Herrmann gave full credit to F. J. Radel, of the Radel Leather Mfg. Co., for perfecting the proposed method of patching to such an extent that the patches could not be detected from the finished side after the coating was applied. Tests showed that the patched part of the split is as strong and flexible as the split itself. In addition to the saving to the car-builders, the method of patching presents an opportunity for large savings by the tanners, according to Mr. Herrmann. The leather specifications proposed by the Subdivision do not recognize patched hides, but it is proposed to revise the specifications as soon as the industry has recognized the value of the patched hides.

Mr. Herrmann also surprised many of the body engineers present by the statement that tests showed that the lowest-priced, or flesh, split is the strongest, the highest-priced, or full-grained, snuffed leather being the weakest; and that although snuffed grain-leather has the softest texture, the



How the Shape of the Hide Affects the Cutting Value
The Square Hide Shown by the Full Lines Gives the Minimum Waste, While the Triangular Hide Outlined by the Dash Lines Is Likely To Be Very Flanky. The Difference in the Cutting Value of the Two Hides Can Be Seen by Comparing the Seat Back *a* as Laid on the Square Hide with the Same Seat Back, Laid Out on a Triangular Hide and Represented by *b*. The Line of the Kosher Trim Is Indicated at *c*

same texture can be produced in other splits by some tanners. The value of these disclosures to passenger-car builders was enhanced by detail figures showing the saving per hide as a result of patching grub-holes and the use of spready hides having a shape more advantageous for cutting. This latter point was emphasized by the statement that the price per hide means comparatively little because the shape has such a great effect on the value of the hide for cutting.

G. W. Kerr, who was chairman of the Subdivision when it was originally appointed in 1920, showed surprise that the findings of the Subdivision indicated that the bottom split is better than grain leather and that grub-holes are, as he expressed it, "no longer a defect." He indicated that if this proves to be the case, the buffing manufacturers will have the leather split entirely into buffing. It was made clear by Mr. Herrmann, however, that, inasmuch as these findings were radical and contrary to present practice, they had not been included in the S. A. E. Specifications, but were disclosed so that those interested could determine by future tests if the Subdivision was following the right lines. He was sure, however, that the Subdivision was 99-per cent right and that the industry would come to appreciate the value of the results obtained.

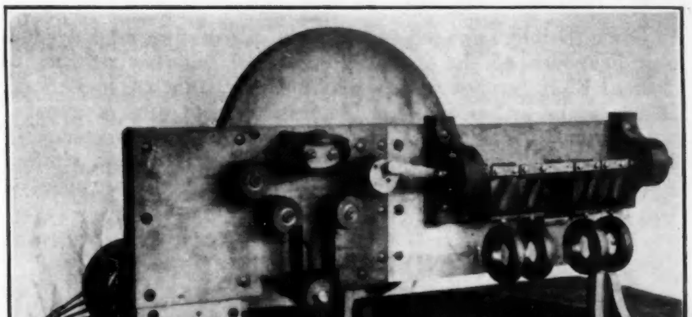
Considerable interest was shown in methods of tanning, splitting and the composition of coatings, but Mr. Herrmann stated that the Subdivision was interested only in results and therefore he did not discuss the manufacturing or tanning in any way. He said, however, that the specifications require that the leather be of uniform thickness. Herbert Chase asked whether the upholstery leather patched as indicated had been submitted to service tests. According to Mr. Herrmann, cars upholstered with this type of leather have proved satisfactory but have not been in service for a great length of time. Samples of patched leather were passed around and created favorable comment as it was impossible to tell the patches from the finished side. As an indication of the perfectness of the patching, Mr. Herrmann said that a tanner was asked to identify the patches in a piece of leather with 16 patches, but was able to locate only 2, the other places selected as being patched being unpatched leather. A considerable difference of opinion was developed as to the strength of the hair side of the hide, belting practice being referred to as proof that the hair side is the stronger. It was noted, however, that the hair side is always buffed, even in belting manufacture.

Mr. Herrmann also brought out the point that, although it would be possible to obtain imitation leather as strong and serviceable as real leather at one-half the cost of real leather, it would not be feasible to use it as the automotive industry is today "sold" on real leather and would not accept imitations. Machines for determining the tensile strength and the wearing qualities of leather were demonstrated by Mr. Herrmann after the meeting. A keen interest was manifested in the model developed for cutting the bevelled hole for the patch.

The joint paper by A. T. Upson and L. N. Ericksen covering the work of the Forest Products Laboratory on the dimensional standardization of wood for automobile bodies was presented by Mr. Ericksen. This paper is printed in this issue of The Journal on p. 161. It was noted that the paper presented constituted but one part of the work undertaken by the Forest Products Laboratory in cooperation with the Special Committee on Hardwood Lumber of the Passenger-Car Body Division; the other part is to be a definite report as to dimensional standardization which will be submitted to the Special Committee.

How Body Upholstery Can Be Improved

In a very constructive paper on body upholstery, H. T. Strong, of William Wiese & Co., mentioned several ways in which body engineers can improve the quality and the appearance of the body and increase the sales value of the complete car. He believes that the period of plain upholstery has had its day and that more attention will be paid to decorative effects in the interior of closed cars, especially by the use of broad lace in the expensive cars and semi-broad lace in the moderately priced cars. He suggested the use of two grades of material, one for the wearing part of the



Machine Developed To Test the Wearing Qualities of Leather
In This Machine a Continuous Belt Was Run Over Rolls. As a Result of Tests with This Machine the No. 1 Split Was Found To Possess the Greatest Resistance to Wear

upholstery and another, of a lighter grade, for the rest of the body.

Mr. Strong stated that the industry is buying carpet on price considerations only and, as it is almost impossible, except for an expert, to detect the use of reworked material or shoddy, the carpet manufacturers resort to the use of such material in an effort to meet competitive prices. The unnecessary expense accruing to car-owners is evident. It was suggested that simple tests, such as counting the ends, or the warp thread, across the width of the carpet, and watching the height of the pile or face, would prevent the acceptance of much inferior carpet.

The use of a mercerized all-cotton fabric at about 35 cents per yd., rather than a silk-warp cotton-filled material at twice the cost, was recommended for low-priced jobs. For medium-price cars, it was suggested that, by the substitution of a fine Sea Island cotton for silk in the filling of the material, a good strong silk would result which would probably give more wear than all-silk material.

A selling argument that is being overlooked today by practically every car-builder, according to Mr. Strong, is the quality of the fabric used in the interior of closed cars. He suggested that, when a change is made in the material, a card be placed on the steering-wheel of every car on the show-room floor describing the material, its wearing qualities and the fastness of the dye, and telling why the material was selected.

During the discussion of Mr. Strong's paper, methods of testing fabric were illustrated by actual experiments. A very simple method of testing the amount of cotton is boiling a piece of the material in a solution of caustic soda that dissolves all of the wool, leaving the cotton as a thin piece of fabric. The necessity of proper weighing scales was emphasized, to avoid misunderstandings. Samples of fabric that are submitted as conforming to purchase specifications frequently are under weight. Samples of cloth were shown which had been "decatized" so that they could not be spotted by water. Mr. Strong stated that unless broadcloth is decatized it is necessary to sponge the entire surface when a spot occurs to raise the nap so the spot will not show.

THE BODY ENGINEERS DINE

Some 60 men engaged in the body engineering and producing branches of the industry gathered together at the informal Body Supper on Tuesday evening, Jan. 22, in Detroit. There were no speeches or discussions, but just a general swapping of experiences and reminiscences. All seemed to have a good time and voted favorably on having a similar gathering of body men held each year under the auspices of the Society.

SAND-CAST ALLOY

Aluminum-Copper-Nickel-Magnesium Alloy for Airplane-Cylinder Castings

In calling the aeronautic session to order, Chairman W. B. Stout remarked that aviation research is culminating in some marked accomplishments and that, having engineered the airplane to support itself in the air mechanically, the time has come when it is expected to support itself financially as well, so that it may emerge from its subsidized position and enter the field of a real industry. The activities of the Society along aeronautical lines are governed largely by a far-sighted outlook into the future, the objective being the betterment of American products, including equipment.

Notes on a Sand-Cast Aluminum-Copper-Nickel-Magnesium Alloy is the title of the paper by Lieut. A. J. Lyon, U. S. A., and Samuel Daniels. It is printed in full elsewhere in this issue of THE JOURNAL, and was read by Lieutenant Lyon. In the discussion that followed, H. A. Huebotter asked whether a section of this alloy having a small cross-sectional area has a finer grain and a higher tensile-strength than one of large cross-section, as is true in the case of cast iron. To this Lieutenant Lyon replied that the effect on tensile-strength is very great in both the cast and the heat-treated conditions because, when the material is heated to the quenching temperature and then quenched, the rate of cooling has a rather pronounced effect upon the resulting physical properties; so, in a heavy section the physical properties will be correspondingly low.

W. C. Keys inquired what effect prolonged rather high temperatures in an engine have on the physical properties obtained by previous heat-treatment of engine parts made of this alloy. No data were available on the hardness after an engine-run of as long duration as say 100 hr. However, from temperature tests, the inference is that the reduction in strength will be less than in the case of other alloys.

Asked whether any trouble occurs in obtaining castings of uniform structure for this alloy, Lieutenant Lyon replied that it is somewhat more difficult to cast than the straight-copper alloy, but that the results in this respect when casting pistons and cylinder-heads had been remarkably uniform. The range of tensile-strength, during about 2 years, for the heat-treated alloy is from 35,000 to 40,000 lb. per sq. in.; and the Brinell hardness is constant within 20 points. Results are remarkably uniform when proper precautions are taken in pouring, gating and chilling, the last being extremely important.

With regard to resistance to corrosion in salt water, this alloy is, it was said, in about the same class as duralumin.

AIRPLANE DESIGNING FOR RELIABILITY

Changes Made in Aeronautical Engines to Reduce the Number of Forced Landings

G. J. Mead, chief engineer of the Wright Aeronautical Corporation, read his paper on the above-named subject. Its main features are as follows:

> Precise and accurate engineering is necessary to increase the reliability of airplanes while at the same time decreasing the weight. Unreliability inspires fear, but the former practice of merely making weak parts heavier cannot be tolerated in aircraft because excessive weight reduces the carrying capacity and consequently the range of action. With these points in view, recent improvements have produced an aircraft engine that will operate for longer periods at higher mean effective pressures than any other type of internal-combustion engine. Several types weighing less than 2½ lb. per hp. have run for periods of from 200 to 300 hr. with but little attention. The Wright E-4, with the same crankcase assembly, the cylinders only being changed, ran for 572 hr. without attention of any kind. Compared with the original Model A, built 8 years ago, the present engine with approximately the same weight and same displacement develops one-third more power, operates at 24 per cent more speed and has 3000 per cent greater durability.
>
> During the war, exhaust-valves, connecting-rod big-end bearings and spark-plugs gave the most trouble. In cylinder construction three difficulties presented themselves: (*a*) the valves warped and burned, (*b*) the valve-seats did not remain true and (*c*) in long runs the valves hammered into the seats so that the tappet clearance was lost and the valves were held open. The various steps that were taken leading up to the present type of cylinder, the adoption of tulip-shaped silchrome steel valves, the use of copper-lead-tin bearings without babbitt lining, and the difficulties encountered in obtaining satisfactory ignition equipment are described in detail. Carbureter development also is said to have progressed. Lack of crankcase rigidity in Liberty engines caused broken camshaft-housings and resulted in failures of the timing-gear. Although the modern shaft transmits 35 per cent more power, its weight is only 17 per cent greater. When running at 350 instead of 420 hp., the Liberty engine has a comparatively long life and weighs 2½ lb. per hp. Duration running has shown that engines weighing less than 2 lb. per hp. are literally torn apart. Refinement of details of the 1947-

in. 60-deg. V-type 12-cylinder Wright T-3 engine has enabled it to be used satisfactorily at speeds greater than 2200 r.p.m. and to develop 750 hp. with approximately 140 lb. mean effective pressure at 20 per cent less weight per horsepower than that of the original engine.

In applying the facts learned from experience to future design, it appears that the points which should receive the greatest consideration are simplicity of design and correct distribution of the proper material, rigidity, dimensional errors and the use of the correct factors of safety, the effect of fatigue, the operating conditions under which the powerplant will be expected to function, lubrication and the storage conditions that will make it possible to protect the engine from rust, both internally and externally. Test results frequently show the need of features not apparent on the drafting-board, such as accessibility for inspection and adjustment, but care must be taken in making deductions from test data that may be inaccurate or incomplete. The performance of production engines is the only reliable criterion of the success of a particular design. The importance of the use of good materials is emphasized, as well as accurate inspection and close tolerances. To secure the best results in operation, specified conditions must be complied with, such as the temperatures of water and oil, maximum engine-speed and minimum oil-pressure; the best mechanism will not operate satisfactorily under adverse conditions.

THE FUTURE OF THE DIRIGIBLE

All-Metal Airships, Construction Fundamentals and Helium or Hydrogen Discussed

Following his introduction by Chairman W. B. Stout, at the aeronautic session held Jan. 22, Ralph H. Upson, chief engineer of the Aircraft Development Corporation, Detroit, gave an interesting address that dealt with the fundamentals of aircraft construction.

Saying that airplanes always will be used for carrying light loads and airships for heavy loads and long hauls, Mr. Upson cited the Barling bombing airplane as being on the dividing line between the two types of aircraft at present but said that, even now, an airship could be built to equal it. He believes the lighter-than-air craft to be best for night service, and said also that the cost of carrying airship freight is more nearly competitive with the present cost on railroads and steamships.

Fundamental Factors

First among the fundamentals cited by Mr. Upson comes fuel. In its recent flight from Lakehurst, N. J., to Western cities and return, the United States airship Shenandoah carried a crew of 48 men; in addition, she could have carried 50 paying passengers. But the actual fuel cost was less than 0.3 cents per passenger-mile.

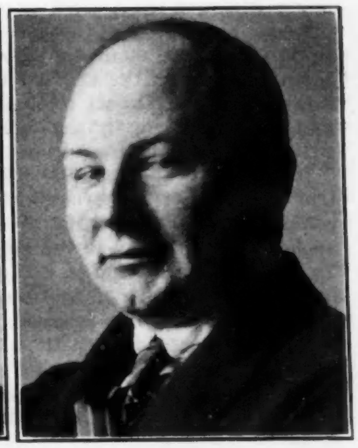
Ratio of structural weight to load carried is the second fundamental and a third is fixed equipment at airship terminals. The airship has no maintenance-of-way expense, but only terminal expense.

Hindrances to Airship Development

Mr. Upson reviewed recent airship disasters, those of the ZR-2, which broke and burned, the Italian Roma and lately the Dixmude having been great deterrents to more rapid development of the airship, but cited the recent exploit of the Shenandoah of returning safely to her base after having been torn loose from her mooring-mast by a gale, and of navigating all night, as proof of the practicability of the airship.

However, an airship of the Shenandoah type is not fireproof on account of the fabric envelope, even when inflated with helium gas; and for the same reason it is not weatherproof. The fabric must be renewed each year. The cost of this would be too great to be borne commercially. The desirable thing, therefore, is to substitute metal for the fabric, the same metal that is used now for the airship framing.

Ralph Upson



Anthony Fokker

Some questions asked brought additional information from Mr. Upson. Replying to Glenn Muffly, as to whether helium would be discarded and the Shenandoah filled with hydrogen, Mr. Upson expressed the hope that this would be done if a flight to the North Pole shall be attempted. One reason is that helium gas has not been considered seriously enough on a commercial basis at enough points of manufacture. Another is the greater lifting-power of hydrogen. The desirable airship will have the ability to use any gas that may be suitable. Helium gas is safer and will quench a fire that it covers, but the use of helium in the Shenandoah has not caused the precautions against fire to be relaxed one whit. It has fire-extinguishers placed every few feet and the fire drill has not been lessened, because the envelope may burn. Mr. Upson pointed out that hydrogen burns only as fast as it can reach the air, and that it does not explode until mixed with air in a proper proportion for explosion.

An airship filled with hydrogen has double the range of action, compared with a ship filled with helium. Although helium has only 7 per cent less lifting-power than hydrogen has, it is handicapped by a 15-per cent less gross-lift. An airship filled with hydrogen can carry 40 per cent more fuel than one inflated with helium. Hydrogen is cheap enough to waste when necessary. The fire risk exists, but it is not so great a risk as is popularly supposed. Zeppelins have a record of 400,000,000 passenger-miles with no casualties. The fire risk is less than 0.1 per cent.

Another question brought the reply that hydrogen can be mixed with helium, to the extent of 15 per cent and that the mixture is still non-inflammable.

COMMERCIAL AVIATION

Its Present Status and Future Trend as Visualized by an Airplane Expert

Those in attendance at the aeronautic session of the Annual Meeting were fortunate in that they could sense the enthusiasm and the knowledge born of practical experience underlying A. A. G. Fokker's exposition of his opinions regarding aviation, as well as benefit from the information he conveyed. For those not in attendance and to this degree less fortunate, the substance of Mr. Fokker's address is presented herewith.

He contrasted this, his third, visit to the United States, with his two previous visits, all within 3 years. Danger was uppermost in the mind of the public when he first came, with a background of great skepticism as to both the immediate and the ultimate possibilities of aviation on a commercial basis. During his second visit, he found business men inquiring seriously into the possibilities of aerial transportation, and beginning to estimate its probable cost and its influence on business. Now, he finds that interest developed more fully and very keen, so that a number of projects are

being initiated with such good financial arrangements that they have a promising prospect of success.

Provisos were made though in that financial backers must carry-on through the inevitable period of commercial-aviation infancy and not expect too-hasty dividends; moreover, manufacturers must supply the requirements of a growing market with truly uptodate equipment.

Noting that the *average time* of even the fastest railroad trains is but little more than one-third of that of a modern commercial airplane, Mr. Fokker expressed surprise that aerial transportation in the United States has not yet reached the status in daily and in business life that it has maintained in Europe since its inception. But, instancing how faster railroad-train service resulting from insistent public demand had been successful even though more expensive to the public as well as to the railroads, he asked: "Who can doubt that, if faster transportation facilities were provided between all large cities, an eager public speedily would take advantage of it?"

Even greater benefits would accrue from aerial merchandise-traffic. Statistics show that, since 1921, such traffic has increased in far greater proportion than passenger traffic on the various aerial lines maintaining regular service across the English Channel. Improved machines reduce the number of trips by carrying large cargoes and thus decrease overhead expense. In the United States an enormous saving in *business time* is needed. To realize the full advantages of aerial transportation, the distance flown must be great enough. Also, successful night-flying is imperative.

Expressing admiration of the progress made by the United States Air-Mail Service, Mr. Fokker said that in some European countries long trips are being made by airplanes in conjunction with over-night railroad-service. The route from Berlin to Moscow is covered by night train from Berlin to Koenigsberg, and by airplane thence to Moscow in 7 hr., a total of 24 hr. end-to-end service in place of a 4-day all-rail journey. Between Toulouse in France and Rabat in Morocco 5 days are required by steamer. Connecting at Toulouse with a night train from Paris, 2 days only are required, with an intermediate over-night stop, by airplane.

For broad and comprehensive aeronautical development to satisfy the geographical conditions in the United States, Mr. Fokker believes it the prime duty of each community to provide aircraft terminals, since they are even more necessary to air transport than are stations to railroads and docks to steamships. He includes in this the possibility that lighter-than-air craft may be perfected so as to justify the present faith of its sponsors. He said further that no city can continue to be counted progressive that is unwilling to provide these vital facilities for the development of aerial transport and, in almost equal degree, that the same applies to smaller and rural communities, inasmuch as it is from the aggregate of the smaller communities that the greater number of future private owners of aircraft will be drawn.

Airplane Possibilities

Some of Mr. Fokker's interpolated remarks are especially interesting in their bearing on the future. He divides aerial transport by airplane into three classes, as follows:

(1) Small airplanes, somewhat on the order of taxicabs, carrying two or three persons

(2) Mail and freight 500-hp. 8 to 10-passenger airplanes

(3) Airplanes of from 1000 to 2000 hp. and upward, for transcontinental and transoceanic flights

Airplanes of the first group might well be used by individuals in both urban and rural districts. His opinion is that 5 to 12-hp. small airplanes will not be successful because they have not sufficient reserve power. For commercial usage, he thinks 50 hp. is the least amount of power desirable, since airplanes need comparatively high power for starting.

In discussing the mail and freight airplanes, Mr. Fokker said that special airplanes for freight-carrying will be placed in service in about 1 year on the London-Paris and London-Amsterdam routes.

Mr. Fokker is certain that we shall have larger airplanes for transcontinental and transoceanic flights and that this development will occur within 20 years.

The key to successful commercial aviation as a public utility and as an industry is a composite one, landing and terminal facilities. When this present lack shall have been overcome, there will be no lack of confidence on the part of the public that will cause it to withhold its patronage. When adequate facilities are provided, the public will utilize aircraft.

At the close of the war, Holland had no flying-fields like those other European countries had. But Rotterdam has spent a half-million guilders for a flying-field and is now the center of the air-lines. In this connection, Mr. Fokker believes that the time will come when each city will have not only one, but several flying-fields. Also, that the dirigible will be used commercially over the extreme long-distance routes.

During the discussion it was stated by W. J. Davidson that air transport must be brought out of the luxury class; tons instead of hundreds of pounds of load must be carried. He asked about the development of types of airplane for carrying heavier loads, and was answered by Mr. Fokker to the effect that only valuable and perishable commodities which must be transported very quickly and are not very heavy are suitable for airplane cargoes. In reply to H. A. Huebotter's inquiry as to the most economic altitude for commercial flight, Mr. Fokker said that for crossing mountain ranges at great altitudes the same airplanes that are suitable for ordinary flying cannot be used. He believes that special routes and special airplanes must be developed for special services, and that most flying for the coming 10 years will be done at altitudes that are not excessive. Asked by O. J. Scherer what the average length of life of a commercial airplane is, he replied that the life of an airplane engine in service is from 1500 to 2000 hr. Mr. Fokker is of the opinion that airplanes will be developed that can be used about 5000 hr. Mentioning that flying at night as well as in the daytime will use the airplane more intensively, so that its life will extend over a shorter period, he said that commercial airplanes rapidly become outofdate owing to development improvements and accordingly must be replaced.

ORDNANCE DEVELOPMENTS

Fascinating Motion-Pictures of New Guns, Tanks and Bomb Dropping

A thrilling feature of the evening session on Jan. 22 was provided by Brigadier-General Joyes, U. S. A., who exhibited to the members and guests present moving pictures of all types of new ordnance materiel, made pertinent running comment on the wonderful fighting machines that appeared on the screen and called attention to the remarkable features of their performance. The films were made during a recent visit of military engineers to the Aberdeen Proving Ground and included some ultra-rapid films in which the movements of guns and automotive equipment were slowed down to a degree that made each detail of recoil, rebound and the like plainly evident.

Members of the audience could see the big and the little guns of all types, see them maneuvered and fired, see airplanes in flight, see bombs of varied caliber dropped, follow their courses and see them strike. A Martin bombing airplane laid a smoke screen before their very eyes. The best known "car" did nearly everything but climb trees when equipped with balloon tires. An amphibious tank with track-layer treads and twin propellers wallowed in and out of marshes, traversed the land and navigated the water with equal facility and indifference and with no apparent damage to itself or its occupants.

As if this were not enough, an anti-aircraft gun equipped with a muzzle brake helped itself to further effort by utilizing the power derived from the velocity of the escaping powder-gases; tanks and vehicles of odd device scurried around in "rough" country and across or through trenches,

and trucks, tractors and trailers performed all sorts of impossible tasks. A stroboscope was shown also. It is a sort of miniature pilot-house mounted on top of the vehicle, such as a tank. It is of projectile-proof material, shaped somewhat like an overgrown helmet, very heavy and mounted on a vertical axis that revolves it at very high speed. Narrow vertical slits are cut through its walls close together around its entire periphery and, due to the persistence of human vision, a person inside can see through the slits that flash past the eye and view the landscape almost as well as if no solid metal were there, oncoming projectiles such as high-powered bullets being deflected and prevented from penetrating by the extremely rapid rotation of the device.

All this and more completely captured the interest of the audience and made it and the Society grateful to General Joyes for his welcome contribution toward making the evening meeting worthwhile.

NATIONAL DEFENSE

How the Automotive Industry Will Serve the Nation in Emergency

Brigadier-General C. L'H. Ruggles

On the evening of Jan. 22, part of the program of the meeting in the great auditorium of the General Motors Building was devoted to authoritative consideration by officials of the Army of the past, present and future relations of the Society to Army problems and Ordnance material. President Alden introduced Brigadier-General Ruggles, who gave an inspiring address having to do with the patriotic service that it is within the Society's power to render in time of urgent and lesser need. General Ruggles is Assistant Chief of Ordnance, U. S. A., and, as President Alden remarked, is one of the very few men in the United States who know fully just what the requirements are in times of urgent National need.

General Ruggles said that the one certain method of preventing an attack by an unprincipled aggressor is to be stronger than he is. The idea that "preparedness" and "National defense" mean aggressive war, necessarily, is wrong fundamentally. The War Department must advise the public what is requisite for National defense. No amount of unwillingness to fight or to defend oneself will prevent unprovoked aggression, but a knowledge on the part of the would-be aggressor that, if he attacks, he surely will be defeated, will deter him as certainly as an unwillingness to defend oneself will encourage him to attack.

Mentioning the geographical factors that hinder attacks upon us and reviewing the requirements of modern warfare, General Ruggles specified quantity and quality of manpower and quantity and quality of munitions as the two decisive factors. Under munitions, and aside from personnel, comes the special relation of the automotive industry to the National defense; for, under this head comes automotive material such as airplanes, passenger cars, motor trucks, tractors and tanks, without which any warring nation would be forced to capitulate. Beyond the railroad termini, the Army must rely upon motor transport not only for its subsistence but for its munitions and, since it seems to be conceded that observation, pursuit and bombing airplanes and airships will play a far greater part in future warfare than they have taken in the past, an adequate air force adequately equipped is of vital importance. The effectiveness of the Army depends upon the effectiveness of its transportation facilities of all types.

But the demands upon the automotive industry will not be confined to such material. The industry must in emergency supply bombs, fuses, guns, gun-carriages, shells and other munitions.

We must keep on hand in time of peace a sufficient reserve of munitions to supply our troops until new production of munitions in quantity can be accomplished. The National Defense Act of 1920 includes the provision that "the Assistant Secretary of War shall be charged with the assurance of adequate provision for the mobilization of material and industrial organizations essential to war-time needs." The guiding principle is to make the plans so complete that nothing that can be provided for by planning in time of peace will be overlooked and so cause confusion and delay under stress of emergency.

Plans of the War Department

Plans prepared by the General Staff of the War Department show what of personnel and of munitions will be needed, in detail; the succeeding steps being the selection of plants in which to manufacture, agreement with their managements as to manufacture and the furnishing to the managements of all necessary information through a decentralized system under which the United States is divided into 14 procurement districts, for each of which a headquarters city is designated and in which city the procurement service is to be supervised by some prominent business-man resident there. For meeting emergency conditions, these district organizations are to be vastly increased. In December, 1923, each district-chief submitted his proposed emergency plans in detail; these will be revised and submitted yearly as the work progresses.

General Ruggles said further that contract forms, sufficiently flexible in their conditions to permit their being executed in times of peace but to become effective only in case of National emergency were being prepared. When signed in time of peace, they are to expire automatically unless renewed after intervals of from 3 to 5 years. But it is evident that, to secure the amount of industrial preparedness desired, there must be whole-hearted and patriotic cooperation by Industry. Therefore, each plant selected for the production of munitions will be urged to work out its own plans for the production assigned to it in as great detail as may be practicable in each case.

The War Department hopes and believes that its plans for the cooperation of Industry will build up an industrial organization so strong that any power or combination of powers will hesitate long before preparing to attack the United States. Hence, it is with the utmost confidence that General Ruggles asks the Society to lend its aid to the War Department in its great effort for continued peace.

THE BUSINESS MEETING

Reports Submitted Show a Growth of the Society Along All Lines of Activity

According to the schedule arranged previously, the Annual Business Meeting was convened at the Hotel Astor, New York City, at the time of the Annual Dinner, held there on the evening of Jan. 10. The tellers of the election of Society officers then made their report, and the business session was adjourned to Detroit for the evening of Jan. 22.

This schedule was carried out, the adjourned business meeting of the Society being convened in the auditorium of the General Motors Building in Detroit on the evening of Jan. 22. President H. W. Alden was in the chair. After calling the meeting to order, he asked for reports from the various committees and from the Treasurer.

Membership Committee Report

Chairman Lon R. Smith, of the Membership Committee, submitted a prepared report that was distribtted to members at the meeting. In this he said that the comparative

total membership in the Society, including affiliate member representatives but not enrolled students, was 5114 on Dec. 31, 1922 and 5053 on Dec. 31, 1923. This decrease of 61 represents the difference between the number of members who resigned, were deceased or were dropped for non-payment of dues in 1923 and those newly elected and qualified.

Including enrolled students, the total number on the roster of the Society on Jan. 1, 1924 was 34 more than on Jan. 1, 1923. Nearly 100 additional students were enrolled in 1923.

It is the feeling of the Committee that the cancellation of membership for the non-payment of dues is strengthening the membership; 471 such members were dropped in 1923.

The Council has been more strict recently in the matter of what men are eligible for any grade of membership in the Society and also in regard to the assignment of applicants to Member grade. The number of applicants rejected in 1923 was nearly three times as great as that for 1922. It is impossible to tell how many men did not qualify or relinquished their membership because they were not assigned to Member grade, but it is known that cases of this kind are not negligible in the statistics presented above.

Efforts made to increase the Society's membership included letters sent to many non-members who have attended the various meetings, to the chief engineers of large motorbus companies and to many production men. A membership campaign was conducted at the Cleveland Production Meeting, and a similar campaign was in progress during the 1924 Annual Meeting. Exhibits are being made whenever advisable of the publications of the Society and of other advantages of membership in the Society.

In 1923, the applications for membership totaled 686; these were classified as to source. Comparison of the results of the different campaigns with the number of applications received, voluntary or unclassified, seems to indicate that the best results are obtained through the holding of good meetings and the publication of satisfactory periodicals, rather than by direct solicitation.

Report of the Meetings Committee

Chairman M. P. Rumney's report for the Meetings Committee noted radical departures from past practice, foremost of which were the holding of the Service Meeting in Dayton in cooperation with the National Automobile Chamber of Commerce and the transfer of the Annual Meeting from New York City to Detroit. He mentioned also the holding of the Summer Meetings in the East as an additional change from custom that is justified on account of the accommodations available and for other reasons, citing the success of the 1922 and the 1923 Summer Meetings as proof, and discussed somewhat specifically the localities most suitable for the holding of the national meetings of the Society.

Attendance at the 1923-1924 meetings, including the 1924 Annual Meeting, totaled approximately 3700 to date as compared with the 1922-1923 total attendance of 2968; in all, 84 papers were presented during the administrative year ended Jan. 25.

Chairman Rumney commended in his report the valuable cooperation with the Meetings Committee given by H. O. K. Meister, for the Chicago Tractor Meeting; by K. L. Herrmann, John Younger and the officers of the Cleveland and the Detroit Sections for the Production Meetings held there; by F. C. Horner for the Transportation Meeting; by A. C. Bergmann for the Annual Dinner; and by the Society's headquarters staff. In conclusion, he extended the thanks of the Meetings Committee to the General Motors Corporation for having provided quarters in which the afternoon sessions of the 1924 Annual Meeting could be held.

Standards Committee Report

Chairman E. A. Johnston then presented the annual report of the Standards Committee, as approved and modified by the Council. This is summarized elsewhere in this issue of The Journal. President Alden announced that it was in order then to move for its acceptance or rejection. Being regularly moved and seconded, it was then voted unanimously that this report be approved for submission to letter ballot of the voting members of the Society.

Report of the Sections Committee

Sections activities for 1923 were reported upon by Chairman H. W. Slauson, of the Sections Committee. In substance, he said that the majority of the Sections had passed the first half of their new administrative year successfully; that, in general, the meetings had been well attended, the speakers and subjects well chosen, and the paid-up Section membership was larger than that of the corresponding period a year ago. A large part of this success he attributed to personal efforts of Assistant General Manager L. C. Hill to imbue the Section officers with enthusiasm for their work and to Mr. Hill's many helpful suggestions for meetings. Chairman Slauson regretted to record, however, the fact that it had been found necessary virtually to discontinue one of the older Sections in a territory that includes more than 150 resident Society members.

The membership ratio, that of Society members to those who are members of their nearest local Section, was criticized; it should be 75 to 100 per cent but averages about 40 per cent only, the highest being 52 per cent and the lowest 20 per cent. This may be caused in a measure by the difficulty of collecting separate dues from Society members to include membership in the parent Society and in the local Sections. Serious consideration is being given to the suggestion made last spring by the Sections Committee that the Society cooperate with the Sections in regard to the collection of Society and Section dues at a stated period, allowing members that so desire to include Section dues on the same check that is drawn to pay dues to the parent Society. If adopted, this practice undoubtedly will be of valuable assistance to many Sections.

This Sections Committee has also recommended that the Sections Constitution be changed to permit the formation of a group of local members or associates who are not members of the Society, and whose privileges shall be restricted entirely to Section activities. The report states also that the Sections Committee feels the problems of Section reorganization have been well met by the committee authorized by the Council for this purpose, which committee is headed by Past-President Bachman. Table 1 was presented and shows Sections membership, meetings held and papers read.

TABLE 1—STATISTICS OF THE SECTIONS

Section	Paid-Up Section Membership 1921–1922	1922–1923	1923–1924[a]	Meetings Held in 1923	Papers Read in 1923
Buffalo	21	45	43	7	7
Cleveland	93	72	141	6	6
Dayton	69	60	23	4	4
Detroit	303	338	331[b]	10	13
Indiana	39	40	43	5	6
Metropolitan	197	236	116	8	10
Mid-West	82	137	93	7	5
Minneapolis	17	19	4	8	12
New England	60	45	33	9	9
Pennsylvania	63	72	2	1	1
Washington	25	17	9	7	9
Milwaukee Group	..	..	..	2	2
San Francisco Group	..	..	..	2	..
	969	1,081	838	76	84

[a] To Jan. 1, 1924.
[b] To Jan. 7, 1924.

Report of the Treasurer

Treasurer C. B. Whittelsey read the following:

The financial report for the year ended Sept. 30, 1923, shows a net increase of $32,298.08 over the report for the same period last year. This is due principally to an increase in revenue from the advertising pages of The Journal, and is a natural sequence of the flourishing business conditions in the industry. This fact should be noted particularly because in periods of business de-

TABLE 2—COMPARATIVE BALANCE SHEET AS OF DEC. 31, 1922, AND DEC. 31, 1923

Assets	1923	1922	Increase	Decrease
Cash	$31,635.70	$17,640.64	$13,995.06	....
Accounts Receivable	42,765.48	62,754.77	....	$19,989.29
Securities, Cost Value	112,814.69	86,513.13	26,301.56	....
Accrued Interest on Securities	1,654.58	1,103.05	551.53	....
Inventories	8,216.79	7,218.94	997.85	....
Furniture and Fixtures	7,947.45	8,186.32	....	238.87
Items Paid in Advance, Charges Deferred	13,293.84	11,843.71	1,450.13	....
TOTAL ASSETS	$218,328.53	$195,260.56	$23,067.97	....
Liabilities and Reserves				
Accounts Payable	$3,812.30	$3,784.76	$27.54	....
Dues and Miscellaneous Items Received in Advance to Be Credited Monthly	56,614.66	58,394.46	....	$1,779.80
Reserves Set Aside for Anticipated Expense	11,323.20	10,019.30	1,303.90	....
Prize-Fund Balance	....	1,044.70	....	1,044.70
General Reserve	146,578.37	122,017.34	24,561.03	....
TOTAL LIABILITIES AND RESERVES	$218,328.53	$195,260.56	$23,067.97	....

pression the Society's finances naturally will suffer and it is necessary therefore not to rely upon this source of income to too great an extent for the establishment of additional permanent benefits. At present, the dues paid by the members are not sufficient to cover the cost of Meetings, Sections, Research, Standards and Employment Service. THE JOURNAL carries the cost of all of the Society's publications, in addition to supporting the above mentioned activities partly. Beginning this year, the TRANSACTIONS will be paid for by the members who wish to have them at the estimated cost of printing, with no editorial or other costs considered.

It is gratifying to note that new members are qualifying more rapidly at this time than at the same time last year, and also that the entire membership is paying dues more promptly. The comparative balance sheet of the Society is presented in Table 2.

REMARKS OF PRESIDENT ALDEN

Prior to the close of the business meeting the retiring president of the Society, H. W. Alden, said he had been pleased greatly during his administration by the two facts that the automotive industry had "come back" and that THE JOURNAL had increased so largely in value as an advertising medium. He enumerated three principal activities of the Society during the last year as having been along the lines of production, transportation and the improvement of highways. A fourth progressive effort has been that of increasing Sections activities, and it is his belief that very possibly this is a line of effort most vital to the Society's future.

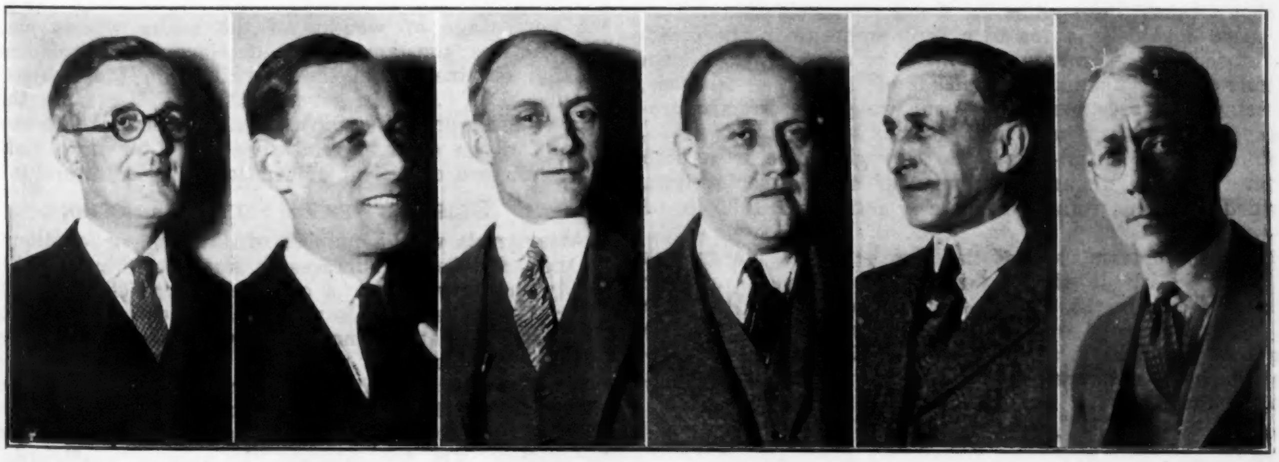
President Alden was especially gratified because of the satisfying contact established by the Society with the American Electric Railway Association in connection with the subject of motorbus transportation, and spoke of the surprise and pleasure this Association had felt over the hearty cooperation accorded it by the Society. He remarked that cooperation with the Bureau of Public Roads is a present Society activity, mentioning also that the destructive effects of highways upon themselves were being studied, in addition to the study of the effects of the vehicles on highway length of life.

Again referring to the problem of Sections organization and maintenance, President Alden said that this vital matter is one with which all associations or societies must contend, but that the Society now has the situation well in hand.

Referring to his relations with associates in the work of the Society during his administration, he characterized them as having been most pleasant, and, in appreciation of the hard work they had done, spoke feelingly of the cooperative effort of the officers of the Society, its committees and its members. Speaking as a business man, he said that the Society's headquarters office is run with most remarkable efficiency by General Manager Coker F. Clarkson and his staff and commended this management highly to the Society members as being one in which their full confidence is justified.

PRESIDENT-ELECT CRANE'S COMMENTS

A brief address by President-Elect Crane concluded the business session. He said that he was impressed strongly by the size of the Society as a business organization, it being one that can expend wisely *an earned income* of $300,000 per year. He believes the real problem of the Society to lie in its being useful to its members, saying that if the Society fails in this respect it cannot succeed.



THOMAS J. LITLE, JR. Lincoln — B. B. BACHMAN Autocar — J. G. VINCENT Packard — E. W. SEAHOLM Cadillac — E. A. DEWATERS Buick — L. C. FREEMAN Maxwell

PROMINENT ENGINEERS PRESENT AT THE ANNUAL MEETING

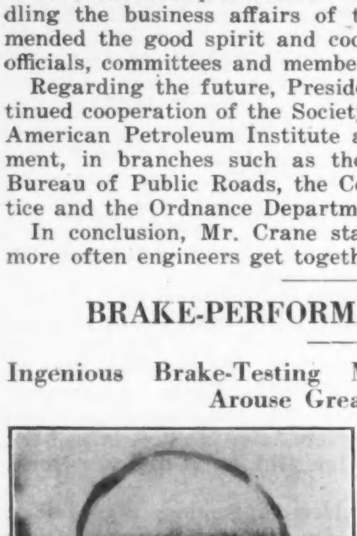
Regarding policies, President-Elect Crane expressed gratification that the 1924 Annual Meeting had been held in Detroit. He likened the Society meetings to cash-and-carry stores to which the members must come and from which the members must carry away the benefits personally. Saying that the Sections exist for the purpose of bringing the Society as a whole closer to its members, he praised the Sections as having been of tremendous value in this regard and cited in proof his belief that some of the best papers and best discussions had been presented at Sections meetings. He hopes to have the headquarters office of the Society assist in handling the business affairs of the Sections. He, too, commended the good spirit and cooperation existent among the officials, committees and members of the Society.

Regarding the future, President-Elect Crane bespoke continued cooperation of the Society in the research work of the American Petroleum Institute and the work of the Government, in branches such as the Bureau of Standards, the Bureau of Public Roads, the Committee on Simplified Practice and the Ordnance Department.

In conclusion, Mr. Crane stated his firm belief that the more often engineers get together for conference, the better.

BRAKE-PERFORMANCE STUDIES

Ingenious Brake-Testing Methods and Apparatus Arouse Great Interest



W. S. JAMES

A paper by W. S. James, physicist, Bureau of Standards, City of Washington, was a prominent feature of the Brake Session. It is hoped that it may be published in full in an early issue of THE JOURNAL but, meanwhile, its most important points are reported briefly herewith.

Mr. James said that the paper makes no attempt to discuss the available braking-forces and their effect on the car's motion; neither does it discuss the several mechanisms used to produce pressure between the brake-drum and the brake-shoe or brake-band. But the means for measuring the braking forces are described and the results of a number of such measurements are given, these including many charts. The paper brings out first some of the more fundamental relations of braking effectiveness, distance required to stop and speed.

When brakes are applied on a car, the reduction in the car speed obviously is due to a force opposite to the direction of motion. The rate at which the car will slow-down depends directly upon the magnitude of this force. Further, the retarding force per unit of car weight is directly proportional to the rate at which the car will slow-down; so, from any fixed initial-speed, the car will come to a stop within the same distance as a car of some other weight, provided the same retarding force is acting per 1000 lb. of car weight.

The decelerometer used at the Bureau of Standards was exhibited. With it the braking force is measured per 1000 lb. of car weight. The method is to measure the force due to a weight of 1 or 2 lb. and calibrate in terms of the weight of the bob; it is the way in which brake effectiveness has been measured by Mr. James and his associates.

In the formula

$$s = K(v^2/a) \qquad (1)$$

where

a = Rate of deceleration
K = Braking effectiveness
s = Distance within which the car will stop
v = Initial speed of the car

the value of a can be stated in terms of feet per second per second, or miles per hour per second, the retarding force in pounds per pound, pounds per 1000 lb. or pounds per ton. The only change is in the value of K. The primary interest lies in the term s, which usually is measured directly when the value of v is known. Since v is squared, an error in obtaining the actual value of the initial speed will exaggerate the value obtained for s.

The term s and the term a can both be measured directly to obtain the term v; in other words, the values for two of the terms must be known to obtain the value for the third term. But, since the retarding force with the present braking system is practically independent of speed, the value for v can be merged with the value for K, which gives

$$s = K_1(1/a) \qquad (2)$$

Equation (2) then shows that the stopping distance is inversely proportional to either the rate of slowing-down or the retarding force in pounds per 1000 lb. of car weight.

Following a description of the decelerometer and of the method of obtaining records, many records were exhibited on the screen and commented upon. In comparing decelerometer records with actual distances measured on the road, the records were found to be correct within 3 to 4 per cent. When measuring from a mark on the road made by firing a pistol actuated by the brake-pedal, the values are erratic. Between the time of giving the order to stop and the actual application of the brakes by the driver, an appreciable delay occurs; for a number of drivers and a number of cars this averaged 0.42 sec. for foot-brake application and 0.51 sec. for the hand brake. At 10 m.p.h., 0.42 sec. is equivalent to a car travel of 6 ft.; hence, the importance of eliminating the driver's reaction is evident.

At high speeds, the results shown by the decelerometer records are erratic; this may be due to the lack of a positive contact between the wheel and the road or to imperfect spring-suspension. With the car in motion, probably the car body is tilted forward somewhat; when the car stops, the body rocks on an axis several times and the instrument, not being able to differentiate between grade and deceleration, records the oscillations. In one instance, for a two-wheel-brake car, the record showed that one wheel had slid over a grease-spot on the road, about 0.8 sec. after the car had begun to stop.

Slides were shown in which the performance of some foreign cars were plotted in terms of distance required to stop; the data were obtained from *La Vie Automobile*. One Hispano car had a stopping rate of from 35 to 36 ft. per sec. per sec., somewhat more than the acceleration of gravity, the coefficient being about 1.12. The other values shown were divided about half-and-half as to whether the braking effort showed increase or decrease with speed.

It was brought out that, in obtaining values of the coefficient of friction between the tires and the road, the greater the percentage of weight on the brake wheels was, the greater was the amount of deceleration. Coefficients of friction obtained from the literature on the subject vary from 0.06 to 0.73. In general, the coefficients for the wet, soft, slippery or greasy pavements are very much lower than those for the drier pavements. The literature makes no reference to a coefficient of friction of more than 1.0.

STARTING VERSUS SLIDING FRICTION

After trials with a number of different tire-sections on a number of different surfaces, it was determined that, practically in every case, the coefficient of friction was higher after the tire started to move than the coefficient required to start it; that is, more pull was required to keep the tire moving than was needed to start it. This surprising result was checked with 14 different tire-sections on different surfaces. Some average values obtained as coefficients were 0.76 for starting on concrete wet with water and 0.98 for sliding. On dry concrete, the average coefficients were 0.72 and 0.50 for starting and sliding respectively. Other tests were made on the following surfaces: rough dry-con-

crete, a varnished desk top, drawing paper, flat rubber, a painted dry-concrete floor, fiber press-board, a woolen blanket, sandy clay and pebbles and wet glass.

Another slide showed values of the coefficient of traction, obtained with the decelerometer; they varied between 0.50 and 0.75. Probably they are not the true values of the coefficient of friction because the wheels may or may not be sliding, but they give some idea of the effective coefficient between the tire and the surface on which it travels, as actually existent in cars on the road.

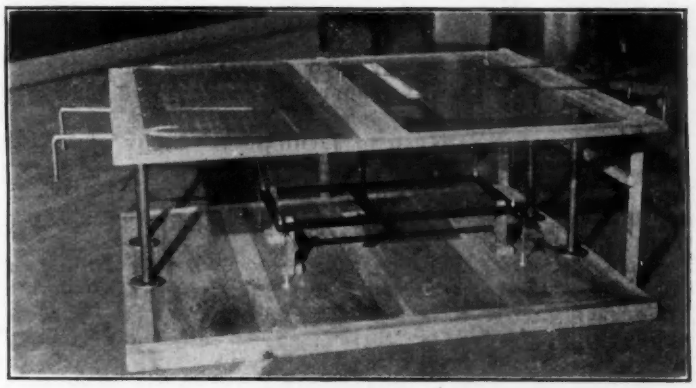
Towing tests of a car having its rear wheels locked were made at speeds up to about 2 m.p.h.; then, the same tire-section taken from the wheel was lowered while weighted with 50 lb. The latter test gave a somewhat higher coefficient than the former, possibly because the unit pressure in the case of the car is from 16 to 18 times the unit pressure in the case of the tire. It was found also that the coefficient of friction is more sensitive to the character of the tire tread than to its configuration. Therefore, if the tire is compressed heavily, as by a 900-lb. load in place of a 50-lb. load, the rubber probably is considerably harder and this may have caused the coefficient of friction to become reduced. This was offered as a possible explanation.

When towing a car over a very wet and slimy wooden bridge, the starting coefficient of friction was approximately 0.65 but it dropped very rapidly; when towing a tire-section weighted with 50 lb. over the same bridge, the coefficient dropped as soon as the tire started to move, although it was not possible to bring the towing speed up to that of the towed car.

Shifting of Car Weight

A compilation of values for rear-wheel weight in connection with maximum deceleration was shown, the average being approximately 53 per cent of the weight when not loaded and 59 per cent when carrying a 400-lb. axle-load. With regard to the shifting of weight between the rear and the front of a car, in comparison with whether it is standing still or being stopped from speed, a table of values was presented which shows the amount of the shifting weight for several different decelerations and heights of the center of gravity of cars. It is obvious that the amount of weight shifted from the rear to the front wheels is dependent upon the ratio of the car's center of gravity to its wheelbase. The decelerometer indicates the effective braking-force whether the car is going up a hill, down a hill or on a level road.

An alignment chart was shown that correlates the relations between the four variables: the center of gravity, the wheelbase, the percentage of the weight on the brake



Unique Model Made at the Bureau of Standards to Study Skidding Action

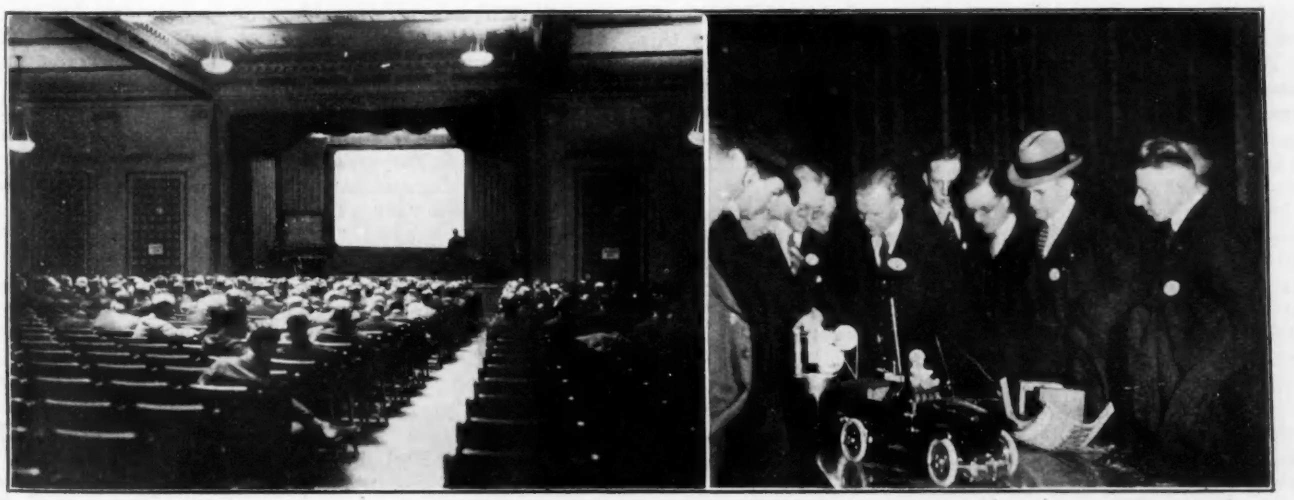
Note the Black Frame Suspended below the Transparent Table-Top by Elastic Bands at Its Four Corners. A Weight, Which Is Not Visible as It Is Carried on the Upright Tube Shown in the Center of the Frame, Represents the Center of Gravity of an Automobile Located with Proper Relation to the Four Corners That Represent the Points of Contact of the Four Wheels on the Road. To Use the Device, a Load Is Applied at the Center of Gravity Thus Displacing the Frame. The Frame Is Then Brought Back to Equilibrium in Its Initial Position by Altering the Points of Support of the Elastic Bands. The Resulting Angle of These Bands with the Vertical Gives an Indication of the Coefficient of Friction Required between the Tire and the Road To Balance the Force That Is Causing a Tendency To Skid

wheels while the car stands still and the coefficient of friction between the tires and the road. From it, knowing the speed of the car, the distance required to stop can be taken.

Some records were made on several cars in actual use, equipped respectively with service and with emergency brakes. These show a very low value for the emergency, or hand, brake. Two records, one with the brakes cool and the other made after the brakes had been heated by dragging for about 1 mile, indicated by comparison that the braking effect had dropped possibly 25 per cent in the second instance.

Special Testing Instruments

Mr. James exhibited an instrument built recently in an attempt to get a convenient means of inspecting brakes in cities. It consists of a pendulum mounted on a weak spring, and the deflection of the pendulum is magnified through linkage and indicated on a scale. Records obtained with this inspection instrument from cars on the road without any special adjustment of brakes show that the service brakes stopped the cars from a speed of 20 m.p.h. in a 53-ft. distance with a deceleration rate of 8.5 and that the



Photographs Taken at Brake Session

The One at the Left Shows the Large Attendance. The One at the Right Shows Group of Members Inspecting Bureau of Standards Brake Exhibit. The Small Model Automobile Is Fitted with Brakes on All Four-Wheels Which Are Controlled Independently by Electromagnets. By Testing This Model with Different Brake Combinations, Skidding Effects and Stopping-Ability Can Be Studied. The Section of a Tire-Casing Shown at the Right Can Be Towed by a Spring Scale and Its Resistance to Motion Measured. The Instrument at the Extreme Rear of the Table Is the Bureau of Standards Recording Decelerometer

emergency brakes caused stoppage from the same speed in an 84-ft. distance with a deceleration rate of 5.2. A simpler form of decelerometer was shown also; it consists of a guarded brass-bound sector having a curved tube filled with liquid and showing an air bubble; it can be used for brake inspection.

An apparatus designed to facilitate the study of brakes and skidding was exhibited also. It consists of a frame supported at the four corners, the frame being weighted so that the center of gravity is located with respect to the four corners in the same position that the center of gravity of a car is located with respect to the points of contact of its four wheels on the road. A load is then applied at the center of gravity in a definite direction and the frame is adjusted again for equilibrium, to its initial position, by swinging the points of support of the equalizing wires to such positions as will accomplish this. Then the angle with the vertical gives the coefficient of friction between the tire and the road. By putting into effect any particular set of forces, as in the case of radii of curvature of a curve or speed on a turn, the apparatus will indicate whether any one wheel will slide or whether it will slip sidewise without having to ascertain this by driving a car on the road.

One other instrument was shown, an unbalanced-couple indicator that is expected to be of material assistance in studying brake performance. The only force that causes skid is the couple that tends to swing the car around a vertical axis. If the car swings at all, an angular acceleration is produced. Therefore, the instrument, which acts as an angular accelerometer, measures the magnitude of the tendency to skid.

Main Points in the Discussion

W. G. Wall believes the James decelerometer to be the best present means of comparing the efficiencies of the different braking systems. In tests made at Indianapolis, the discrepancy between the decelerometer results and the actual measurements seemed to be due to errors in the physical measurement. Causes are the difficulty of getting a driver to apply his brakes at any particular instant, inaccuracies of the speedometer and its gearing and the method of applying the brakes. The decelerometer results were very consistent and showed little variation between the different braking systems. Cars running at 20 m.p.h. showed only a maximum difference of 1½ ft., or about 8 per cent. This might easily be caused by a difference in the method of applying the brakes, rather than by a difference in design.

It was stated by A. W. S. Herrington that laws were being enacted in some States requiring car-owners to submit their cars for a braking-deceleration test, with the requirement that it correspond to 10 ft. per sec. per sec. He said that most cars can meet with such a requirement with the foot-brake but not with the hand-brake. He believes this to be a serious problem that eventually will revert to the automotive engineer unless such legislation is obviated in some way. With reference to four-wheel brakes, he said that their advantage consists not so much in quick stopping as in safe stopping, in comparison with stops produced with two-wheel brakes.

In response to a question by O. M. Burkhardt regarding possible changes in the brake-lining after a certain distance had been traversed by the car in a decelerometer test, Mr. James said that he doubted the possibility of obtaining such data with the decelerometer and advocated some simpler method. Referring to Mr. Herrington's remarks, Mr. James emphasized them and said also that conditions of deceleration are being prescribed which are impossible to meet. He said that the New York City requirement of a 37-ft. stopping-distance from a 20-m.p.h. speed cannot be met unless the coefficient of friction between the tire and the pavement is high.

Cornelius T. Myers asked if a comparison had been made between the decelerometer described by Mr. James and the Wimperis decelerometer. Mr. James said that no such comparison had been made.

Credit is due Past-President Bachman for his apt statement of his failure to understand how a coefficient of friction between a wheel and the road can be greater than 1.0 He said that, seemingly, such a coefficient can be obtained only by dragging a cat backward by its tail across a floor. Mr. James replied that there is no particular reason for limiting the value of the coefficient of friction, that it means that the angle of repose will be greater than 45 deg. and that he could not explain it further. He instanced that rubber on glass necessitates a greater pounds-pull to move it than the pounds of weight placed on the rubber.

Upon motion duly made and seconded, it was voted to extend expression of appreciation to Mr. James and to the Department of Commerce for the paper he presented, specifying that this work is of great benefit to the public at large and recording the hope that work of this character will be continued.

FOUR-WHEEL-BRAKE DESIGN

Real Problem Is Satisfactory Operation Regarding Pedal-Travel and Pedal-Pressure

An important contribution to the success of the Brake Session was made by Henri Perrot, consulting engineer, Paris, France, one of the pioneers in four-wheel-brake design. His paper is printed elsewhere in this issue of The Journal.

Briefly stated, he first reviewed four-wheel-brake development. Then, quoting from other authority, he said that front-wheel brakes have a direct retarding effect on the motion of translation when a four-wheel-brake car rounds a curve and, in addition, a direct retarding effect upon the instantaneous motion of rotation of the car about its own center of gravity. Further, he quoted authority for the theoretical advantage of four-wheel-brakes on heavy downgrades.

From the driver's viewpoint and with reference to pedal-travel and pedal-pressure, he said that satisfactory operation constitutes the real problem. He made comparisons between internal-expanding and external-contracting types of brake and discussed the servo-brake with reference to the Perrot system. In conclusion, he cited seven specific important items that should govern all four-wheel-brake designs.

Answering a question that followed his paper, whether diagonal compensation of four-wheel brakes interferes with steering-ability, M. Perrot said that he still feels that diagonal braking is not only good but safest; however, he finds difficulty in getting other engineers to agree to this.

Front-Wheel-Brake Release

J. G. Vincent, vice-president of engineering for the Packard Motor Car Co., discussed at some length the equalization of front-wheel brakes and internal versus external types of brake. Mr. Vincent said in part that he would like to know just why the outside front-wheel brake should be released when rounding curves with a car. He amplified his reason for this query and then said: "We have gone so far in analyzing this problem as to write the equation of the path of the car under the varying conditions, and the results of this analysis are covered by the following summary":

(1) All things being equal, such as car speed, road conditions and the like, a greater loss of directive control of the car occurs with rear-wheel skidding than with front-wheel skidding. At low speeds, neither kind of skidding is serious. But at high speeds the control, once lost because of rear-wheel skidding, cannot be recovered. With front-wheel skidding, no change in the quality of the momentum of the car takes place; hence, the control is recoverable by releasing the brakes somewhat

(2) In braking systems in which most of the braking action takes place on the rear wheels, locking controls the point where skidding commences.

Under such conditions, the car will move in a straight path only so long as the rear wheels are equalized perfectly

(3) With the rear wheels locked and with the car moving in a straight path, the rear end will skid just as soon as a turning tendency is exerted on the car. This may arise from unequalized front brakes or be due to any deviation of the front wheels from the path of motion of the car. This peculiar action of the car under these conditions can be likened to the juggling of a straight rod on its end. So long as the rod is kept in the position in which the center of gravity is directly above the point of support, nothing happens, but the slightest displacement of the center of gravity from the true vertical causes an increased displacement and the rod topples over; in other words, the condition is unstable. At low speeds an experienced driver can compensate somewhat for these turning moments but, at high speeds with a sudden deviation, the car gains considerable momentum when the skidding commences and, generally, the car turns through a very large angle and comes to a stop before the driver realizes what has happened

(4) With the rear wheels locked when rounding a curve, the release of the outward front-brake applies a considerable turning moment on the car which, acting in addition to the centrifugal force, greatly augments the turning tendency of the steering forces; hence, the rear wheels skid out much more easily

(5) Due to the loss of braking effort of the front wheel, which is released, the deceleration of the car is much lower, and the critical skidding point occurs at low braking-rates

(6) It can be shown mathematically that, for two cars having the same distribution of weight and the same distribution of braking effort for straight-ahead driving, all other conditions being equal, the car that does not release the outer brake can turn a shorter curve without skidding than can the other car

(7) The foregoing statements are based upon a comparison of two cars that are identical except for the way in which the brakes are applied. Another very important element has been found after mathematical analysis to have an important influence; it is that some cars require greater directive effort than others. In other words, due to the location of the center of

GEORGE L. SMITH

HENRI PERROT

gravity with reference to the front wheels, skidding is more prevalent where the center of gravity lies well forward along the wheelbase. It would be perfectly possible to cause a front-wheel skid without brakes, in any car, by giving the steering-wheel a very sudden wrench; but the car that will skid the easiest will be the car that has its center of gravity farthest forward

INTERNAL VERSUS EXTERNAL BRAKES

Mr. Vincent's discussion of the subject of internal versus external brakes follows:

The internal-expanding brakes are unquestionably, from all points of view, the most desirable and logical type of brake to use on the front wheels. The designs generally can be made more neat in appearance, and the controls can be more easily and more simply arranged. Due to elastic conditions of the front-axle system and its mounting with front springs and steering connections, automatic servo-characteristics such as those obtained with external brakes are undesirable because of the liability to danger. The self-compensating action of internal brakes due to expansion in braking periods of long duration is a feature of very great merit.

When it comes to rear brakes, however, the problem is somewhat different. If an entirely separate set of emergency brakes is to be provided either for the purpose of complying with legal requirements or as an added safety feature, a propeller-shaft brake must be supplied or else an external-contracting brake must be

W. R. STRICKLAND, Cadillac — W. E. LAY, University of Michigan — F. W. MARMON, Marmon — HIRAM WALKER, Chandler — G. H. KUBLIN, Moon

PROMINENT ENGINEERS PRESENT AT THE ANNUAL MEETING

fitted to the rear axle. The many objections to propeller-shaft brakes are well known; hence, the general tendency, and the most logical thing to do, is to supply two sets of brakes on the rear axle. If both sets are fitted, it is optional with the maker as to whether he shall use the internal or the external brakes for service. The preference is to use external brakes for service, and it can scarcely be denied that taking advantage of the self-acting principle of the external brakes is a sensible thing to do.

T. J. Lítle, Jr., spoke of the degree of pedal-pressure required; he said the amount of pedal-pressure needed must not be excessive. With some brakes of the internal type, too much pedal-pressure is required; therefore, he said, the design must be improved. Mr. Lítle stated further that a servo mechanism is not desirable and that he prefers direct brake-application.

With regard to the release of the outer front-wheel brake on a curve, W. R. Griswold gave as his opinion that such release is not necessary so long as the rear wheels are responsible for most of the braking effort. M. Perrot then stated his opinion that, on present American cars, the full braking effect on the front wheels is not being obtained. He said also, in reply to B. B. Bachman's query regarding the proper distribution of braking effect between the front and the rear wheels, that the European cars are equipped to provide a larger proportion of the total braking effect on the front wheels than is required of front-wheel brakes on American cars. From Mr. Perrot's experience, he believes it best to reduce the amount of braking on the outside front-wheel when rounding a curve. The Perrot distribution of braking effect for touring cars was stated to be 50 per cent for the front and 50 per cent for the rear wheels; for racing cars, 65 per cent for the front and 35 per cent for the rear wheels.

Herbert Chase inquired concerning the advantages and disadvantages of the inclined knuckle-pivot and the vertical knuckle-pivot. O. M. Burkhardt said that the car he represents uses the vertical knuckle-pivot because its equalizing forces are balanced through the tie-rod.

In M. Perrot's opinion, more development work remains to be done on the steering system and on the spring-suspension than on the front-wheel brakes themselves.

BRAKES AND BRAKING FORCES

Balanced Forces, Brake Performance and Four-Wheel Brakes Analyzed

On the morning of Jan. 23, the Brake Session of the 1924 Annual Meeting was convened in the auditorium of the General Motors Building at Detroit. W. R. Strickland was chairman and many interested members and guests were present.

George L. Smith, designing engineer for the United States Ordnance Co., City of Washington, presented the first paper, its subject being the Theory and Advantages of Balanced Brake-Forces. The full text is printed elsewhere in this issue of THE JOURNAL, but a brief resume is included here as a preface to a summary of the discussion that followed the paper's presentation.

Mr. Smith described the two methods of brake application in use in the United States and propounded the theory of balanced brake-forces, passing then to a comparison of these methods and making comments upon them. He presented illustrations and used them to analyze the brake-forces and the practical application of an equalizing mechanism used in road tests of an automobile. Tests on wet pavements were made and skidding was studied. The skid-checking effects were noted, and these were explained by Mr. Smith.

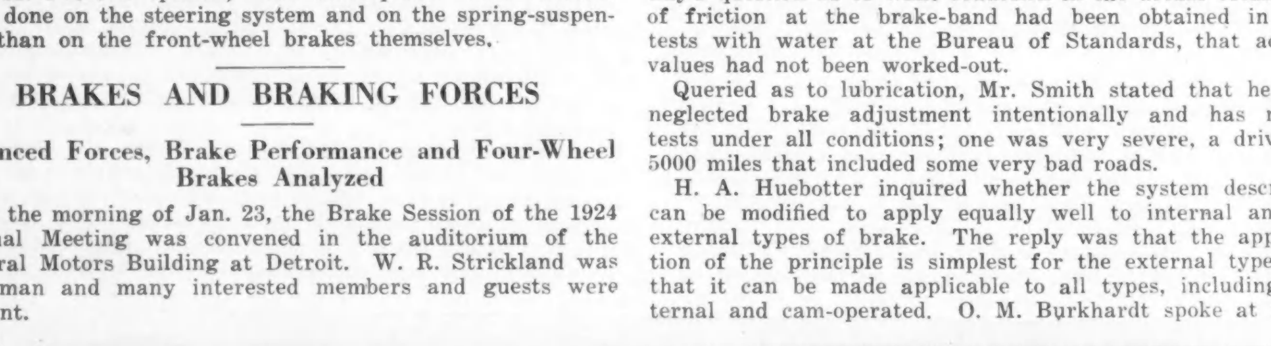
He included the results of additional tests on hills and presented details of the effects of speed and pressure. Further details of wear on the tires and on the brake-lining were included, as well as explanations of the effects on steering ability. An automatic signal that brake adjustment is needed was described, together with details of the measurement of individual brake-force.

Questions followed the delivery of the paper as to the variation of the coefficient of friction. Mr. Smith said that the rigging can be made either sensitive or sluggish. The first rigging had a lever-arm 4 in. long and a 3/8-in. up-and-down movement of the anchor stud. Asked by J. H. Hunt concerning the effect if one wheel were to lock when on a surface of ice, Mr. Smith replied that such a condition transfers the question from the brake rigging to the road surface.

In reply to Chairman Strickland's query as to the calculation of the percentage of loss of braking effort, Mr. Smith answered that the maximum braking effect is obtained when the coefficient of friction is the same on each brake. As the coefficient on each side changes, if the mean value remains the same the total force is greater than when one side is high and the other low. He said also, answering W. E. Lay's question as to what reduction in the actual coefficient of friction at the brake-band had been obtained in the tests with water at the Bureau of Standards, that actual values had not been worked-out.

Queried as to lubrication, Mr. Smith stated that he has neglected brake adjustment intentionally and has made tests under all conditions; one was very severe, a drive of 5000 miles that included some very bad roads.

H. A. Huebotter inquired whether the system described can be modified to apply equally well to internal and to external types of brake. The reply was that the application of the principle is simplest for the external type but that it can be made applicable to all types, including internal and cam-operated. O. M. Burkhardt spoke at some



W. B. STOUT, Aeronautic Session — R. E. WILSON, Research Session — JOHN YOUNGER, Production Session — E. A. JOHNSTON, Standards Committee

FOUR OF THE ANNUAL MEETING CHAIRMEN

J. A. C. WARNER

ROGER BIRDSELL

length regarding conditions that cause brake chatter and brake gripping and those in which a wheel leaves the ground. He said that a frozen brake can scarcely be avoided without adding more linkage on brakes that are adjusted very close. Mr. Smith replied that there is little or no tendency for one brake to grab, since the adjustment is tight enough to give almost no clearance and one brake cannot grab unless another brake grabs also. Tests made for chattering showed that it does not exist except when the pivots are loose.

RESEARCH PROBLEMS REPORTED

Research Session Papers Cover Fuel Investigation and Radiation Determinations

As a part of the fuel investigation undertaken by the Society, the American Petroleum Institute, the National Automobile Chamber of Commerce and the Bureau of Standards, a series of road-service tests of fuels of different volatilities was conducted during the winter of 1922-23 by a number of automobile builders. Most of the results were reported at the 1923 Semi-Annual Meeting of the Society and in THE JOURNAL for July, 1923. But the dilution and oil-consumption data, which were not available at that time, have since been worked up and were reported at the Research Session by J. A. C. Warner, assistant manager of the Society's Research Department. The paper is printed on p. 151 of this issue of THE JOURNAL under the title, Winter Tests Show Greater Dilution with Heavy Fuels.

The discussion that followed the paper brought out a number of interesting points. Of particular importance were the written contributions on the dilution problem presented by a large number of leading automobile builders. It is hoped that this material will be presented in THE JOURNAL at an early date.

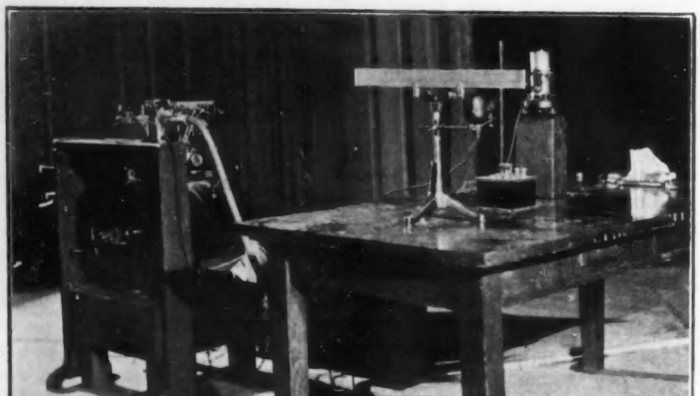
COOPERATIVE FUEL-TESTS REPORTED

Chairman R. E. Wilson called upon Roger Birdsell to present a report, which will appear in an early issue of THE JOURNAL, on the cooperative fuel investigation. Mr. Birdsell said in part:

> This paper is a progress report of the fuel investigation now being conducted by the Bureau of Standards in cooperation with the American Petroleum Institute, the National Automobile Chamber of Commerce and the Society of Automotive Engineers. It discusses results obtained since June, 1923, when a progress report was presented to the Society at its Semi-Annual Meeting.
>
> The primary object of this investigation has been to obtain adequate data for estimating satisfactorily the effect of certain changes in fuel volatility upon the performance of automobiles now in service. For this purpose four fuels designated by the letters, *A*, *B*, *C* and *D*, were selected.
>
> The program that was outlined and is being followed in this investigation is as follows:
>
> (1) Fuel-Consumption Tests—Summer Conditions—on Road
> (2) Crankcase-Oil Dilution—Summer Conditions—on Road
> (3) Fuel-Consumption Tests—Winter Conditions—on Road
> (4) Fuel-Consumption Tests—Winter and Summer Conditions—Constant Speed and Load—Laboratory Set-Up
> (5) Crankcase-Oil Dilution—Winter and Summer Conditions—Constant Speed and Load Laboratory Set-Up
> (6) Accelerations—Winter Conditions—on Road
> (7) Accelerations—Winter and Summer Conditions—Laboratory Set-Up
> (8) Starting
>
> The purpose of this program was to obtain data that would be instrumental in answering the paramount question of whether the overall cost of transportation would be reduced by the use of a fuel such as *D* instead of one of a higher volatility such as *B*.
>
> The results of items 1 and 2 in the above-mentioned program were given in a report made by R. E. Carlson to the Society and published in the February, 1923, issue of THE JOURNAL. Items 3, 4 and 5 were covered in a similar report made by the late S. M. Lee to the Society and published in the July, 1923, issue of THE JOURNAL. This paper will cover items 6 and 7, accelerations, both on the road and in the laboratory. Item 8 is not completed, having been held up on account of the explosion last fall that wrecked the laboratory set-up.
>
> ACCELERATIONS
>
> From preliminary tests it did not appear that the difference between the performance, during acceleration, of fuels *A*, *B*, *C* and *D* were very marked. Further efforts therefore were concentrated on fuels *B* and *D*, the *B* fuel corresponding rather closely to the average 1922 commercial fuel, while the *D* fuel has the lowest volatility of any of those under consideration.
>
> The purpose of the tests was primarily to answer the two following questions:
>
> (1) Are the rates of acceleration obtainable at any given temperature different for the fuels compared?
> (2) When carbureter settings are such as to give maximum acceleration with each fuel, will the fuel consumption under constant speed and load conditions be greater with one fuel than with the other?
>
> For the road tests of acceleration under winter conditions cars *W* and *Z*, fuels *B* and *D*, and a course 0.3

H. H. MCCARTY

THOMAS MIDGLEY, JR.



SET-UP USED IN DEMONSTRATION BY THOMAS MIDGLEY, JR., AT THE RESEARCH SESSION
The Single-Cylinder Engine at the Left Is Fitted with a Small Quartz Window Opening through the Cylinder-Wall into the Combustion-Chamber. A Thermocouple Is Mounted Directly in Front of This Window So That It Is Affected by the Radiant Energy of the Combustion. This Thermocouple Actuates the Galvanometer Shown Mounted on the Box at the Rear of the Table. The Galvanometer Projects a Circular Spot of Light onto the Horizontal Glass Scale Shown Supported by the Stand at the Front of the Table. Any Change in Radiant Energy Is Indicated by a Transverse Movement of the Spot of Light on This Scale

mile long were used. The course selected was an asphalt road, in good condition and practically level. The tests were made by driving the cars at a constant speed of 10 m.p.h. while approaching the course and then accelerating for the 0.3 mile by opening the throttle wide. During an acceleration the speed at 2-sec. intervals was obtained by a recording tachometer, the fuel consumption was measured in cubic centimeters, the time over the course was taken with a stop-watch and general weather conditions were noted.

For the laboratory tests, the *Z* engine was used. On the end of the dynamometer armature shaft was mounted a steel disc of such dimensions that its inertia added to that of the armature equalled the inertia of the *Z* car.

The general conclusions reached are that

(1) Under all conditions very nearly the same rate of acceleration is obtained with the *D* fuel as with *B*, but under cold conditions more of the *D* fuel is required for maximum acceleration than of *B;* not as much more, however, as the estimated possible production

(2) Maximum acceleration occurs at the carbureter setting giving maximum power at 600 r.p.m., full throttle

RADIATION CHARACTERISTICS OF ENGINES

Thomas Midgley, Jr., presented a paper, printed on p. 178 of this issue of THE JOURNAL, on Radiation Characteristics of the Internal-Combustion Engine. H. H. McCarty is co-author. A demonstration was given to show the radiation characteristics of a small internal-combustion engine operating under different conditions.

In the discussion, Mr. Midgley stated that radiation increases as the compression pressure increases, but only to a slight degree so long as detonation does not occur. It was also brought out that the radiation does not throw much light on the causes of detonation. The amount of energy liberated was stated to be entirely independent of the temperature.

Mr. Midgley reported that a reasonably satisfactory calibration of the apparatus had been made but that complications arose when an attempt was made to estimate the number of British thermal units striking the cylinder walls.

Benzol fuels and alcohol were said to give perfectly normal indicator-cards in contrast with those from real anti-knock materials. Radiation increases with the spark-advance until a point of high over-advance is reached and then a decrease is noted.

SPARK-PLUGS MAIN CAUSE OF DETONATION

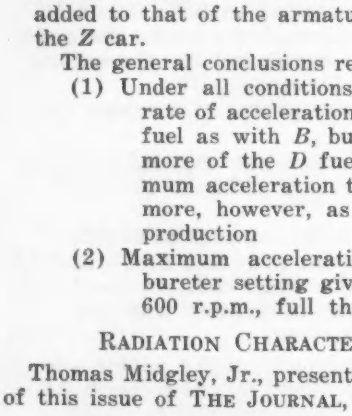
Special Plugs Designed So Other Causes of Detonation Could Be Studied

A paper on Controlling Detonation under High Compression, prepared jointly by J. H. Holloway, of the Purdue University Engineering Experiment Station, and Prof. G. A. Young, director of the mechanical engineering laboratories at the same university, was presented by Mr. Holloway at the Passenger-Car Session.

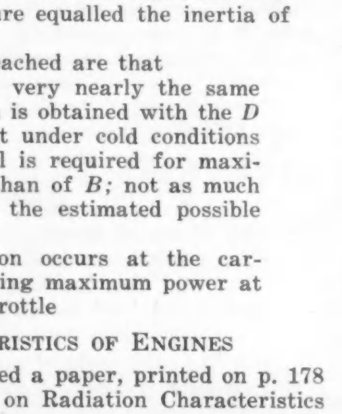
A compression pressure without detonation of from 150 to 175 lb. per sq. in., obtained by the addition of a small amount of anti-knock compound to the fuel with enough increase in efficiency to warrant the additional expense, is considered feasible, as a result of the experiments carried on during the last 2 years, provided reasonable care is exercised in maintaining the proper temperature of the mixture, the spark-plugs, the valves and the combustion-chamber walls. The results of the first part of the investigations, which were printed in the January, 1923, issue of THE JOURNAL on p. 111, were reviewed together with the work carried out during 1923.

It was found that aluminum-alloy pistons with thick heads, well-ribbed and with four piston-rings, made it possible to carry a compression pressure of 125 lb. per sq. in. without detonation, which would be impossible with cast-iron pistons. The first cause of detonation was found to be commercial spark-plugs. It was therefore necessary to design special spark-plugs so that detonation caused in other ways could be studied. Experiments showed that spark-plugs could be designed and built to operate at low enough temperatures not to produce detonation and yet be practical from a production standpoint. It was found that with most favorable conditions as to the temperature of valves, spark-plugs and combustion-chamber walls, a compression of 130 lb. per sq. in. is high enough to detonate the charge after the spark has passed. With present-day low-grade fuel in engines of the poppet-valve type with properly cooled combustion chambers, spark-plugs and valves, a compression pressure of 110 lb. per sq. in. can be used without an undue amount of a carbon cleaning being involved. It was found that when proper care had been exercised in eliminating hot-spots, using properly designed spark-plugs and delivering a cool mixture to the combustion-chambers of a sleeve-valve engine, a maximum compression-pressure of 125 lb. per sq. in. could be used without detonation.

The next paper was presented by C. E. Sargent on the Essentials of a Successful Constant-Compression Engine. This paper was printed in the January, 1924, issue of THE JOURNAL on p. 5. N. S. Diamant, of the Jamestown Car Parts Mfg. Co., then presented a paper on Engine-Cylinder-Cooling Notes and Radiator Operating-Characteristics, which, it is expected, will be printed in an early issue of THE JOURNAL. In the first portion of the paper a general



G. A. YOUNG



J. H. HOLLOWAY

quantitative comparison of air, water and oil-cooled cylinders is given as it relates to the subjects of heat-transfer and temperature-drop. The discussion is not corroborated by experimental data, but the assumptions are stated clearly and a large range of values is covered in a table so that any desired values can be chosen. A thorough and comprehensive discussion of steam or the radio-condenser type of cooling is presented under the headings of steam cooling systems, characteristics of steam cooling, cooling capacity of radiators used to condense the steam and the present state of development.

In the second portion an attempt is made to give a thorough but brief discussion of the performance or of the operating characteristics of radiators from the viewpoint of the car, truck or tractor designers. The cooling of aircraft engines is not considered. A great amount of original material is contained in this second portion which should prove not only of direct value and use, but also of indirect value by interesting others in the solution of cooling problems.

In connection with the discussion that followed the presentation of the papers, questions were written on cards which were turned over to the authors in time to allow them to study the questions before the discussion of each paper was opened. Chairman Lítle stated that this procedure resulted in more and better questions, but removed some of the personal element in view of the fact that the names of those submitting the different questions were not given.

In opening the discussion, Mr. Lítle stated that, because engineers have been busy with production problems, few changes in engine design have been made, and that Mr. Sargent's paper was of particular interest as it threw considerable light on the engine of the future. In answer to the question as to where the special spark-plugs described could be secured, Mr. Holloway stated that they were not commercially available; but sample spark-plugs were passed around showing the construction. In reply to a query as to the gain in thermal efficiency obtained by the use of high compression, it was said that there was a 26-per cent increase in the brake thermal efficiency and a 25-per cent increase in the power, which was slightly less than that obtained during 1922, probably due to the fact that the tests in 1923 were made on the road with all accessories driven by the engine. In answer to the question as to the maximum difference in the compression-ratio made possible under the best spark-plug conditions, the other conditions being approximately the same, Mr. Holloway stated that an increase in pressure of from 30 to 40 lb. gage was possible. Replying to other questions, Mr. Holloway said that with the long manifold around the front of the engine, no indication of loading, of lag in acceleration or of uneven distribution was noticed. In regard to the effect of the length of the water-jacket below the combustion-chamber on the detonation control, Mr. Holloway stated that they experienced no effect. In the matter of whether a short jacket would tend to cause more uniform cylinder-temperatures with higher average temperatures, Mr. Holloway did not consider such practice desirable. As Mr. Holloway did not run any acceleration test, he was unable to state whether the long inter-cooler required more gasoline for acceleration than was required by the shorter manifold. He expressed the opinion that porcelain is better for spark-plugs than mica as it has better heat-conducting characteristics. As to whether the hot porcelain or the ignition points caused preignition or detonation, it was thought that both were responsible, depending upon their temperature.

In reply to a question whether the tests had been extensive enough to develop a normal coat of carbon, Mr. Holloway stated that they had been of sufficient duration to do this. It was noted that the expression used by the author, "cool dry mixtures," was rather contradictory. Mr. Holloway said that the mixture was only relatively cool, being about 125 deg. fahr. He had no data as to means of controlling the temperature of the intake air.

As to the points in the combustion-chamber mostly at fault in causing detonation, the spark-plugs and the exhaust-valves gave the most difficulty. Mr. Holloway was of the opinion that the pump cooling-system is more effective than the thermosiphon system, as the speed of the water in the first system brushes off the steam bubbles. He said that the high compression had a deleterious effect on the bearings and that a slight roughness of operation that was perceptible through the entire speed-range and was also due to the high compression occurred. Assuming the normal amount of carbon cleaning, Mr. Holloway stated that approximately 25 to 30 lb. per sq. in. increase in the compression pressure was possible with aluminum pistons as compared with cast-iron pistons. In reply to a request for the reason for the square section of the inter-cooler if the charge were dry, it was stated that the dry mixtures were not obtained at all conditions as expected.

C. H. Schweitzer submitted a written discussion of Mr. Sargent's paper in which he took issue with the author's statement that "with only a pure mixture without free fuel reaching the combustion-chamber perturbation or turbulence is superfluous," indicating that the author did not understand the function of turbulence, the most important effect of which is the speeding-up of the combustion. To this Mr. Sargent replied that it is impossible to increase the power with a homogeneous mixture by the use of turbulence and

C. E. Sargent

N. S. Diamant

that inflammation can be so rapid that the heat generated will be absorbed by the cylinder walls without doing useful work. In reply to another question submitted by Mr. Schweitzer in his written discussion, the author stated that it is possible to draw the heavy ends from the heating chambers when the engine is idling, but that they would not flash in an open pan; that no heavy ends were accumulated during heavy loads; and that kerosene would be just as satisfactory as gasoline.

Mr. Sargent stated that the 17-per cent gain in fuel economy at light loads was low and that much better results must be expected; that carbon was not accumulated as a result of cracking the fuel in the exhaust heating-chambers, although it was found that the heating chambers did accumulate the dirt that had been removed from the air; that the rollers bearing on the tapered cams had round surfaces; that no evidence of wear was found on the cams and followers; and that so far as could be determined the fans did not cause sluggish acceleration.

The number of revolutions per minute of the engine at the maximum horsepower was 1000. It would idle at 300 r.p.m. Mr. Sargent said that, although the camshaft had been difficult to make, it would be possible to make it economically in production with a milling cutter.

In the discussion of Mr. Diamant's paper, the author stated that the most efficient speed for the passage of air through the radiator core under average operating conditions is approximately 25 m.p.h., but depends largely on the resistance of the radiator to the air; that the problems connected with oil-cooling require considerable study before the merits of this system can be determined definitely; that, owing to the low boiling-point of alcohol, the temperature

at which a steam-cooled engine will operate in the winter with an alcohol solution is about 180 deg. fahr.; that it is very necessary to use a fan with the steam-cooling system; and that with this system it is possible to bring the water to the boiling-point in from 1 to 2 miles. In connection with other questions submitted in regard to the proper design of radiators, Mr. Diamant emphasized the fact that his paper was intended to deal primarily with operating characteristics rather than design.

The point was brought out that the use of steam-cooling systems requires less copper for the radiator than the thermosiphon system, the ratio for the amount of copper necessary being approximately from 1.0 to 1.3 for an assumed outside temperature of 80 deg. fahr. Considerable discussion as to the feasibility of using oil as a cooling medium followed, it being stated that the difference in the summer and winter operating temperatures had been found to be not over 10 deg. It was thought that higher economy might be expected, but it was recognized that several disadvantages must be considered. Neil MacCoull stated that the use of oil as a cooling medium has under certain conditions caused detonation, which indicated that the higher operating temperature made it possible for certain points in the cylinder to heat-up sufficiently to cause detonation, which was not experienced with water in the radiator.

Dr. H. C. Dickinson considered that the possibilities in the use of cooling mediums that would permit higher operating-temperatures were very great, citing particularly the results of recent tests which showed that crankcase oil-dilution is determined largely by the average operating-temperature, the higher the temperature the less dilution being caused.

CARBURETION AND MANIFOLDING

Carbureter Research at Purdue University Reported—Swan Type Manifold Described

At the Fuel and Engine Session of the Annual Meeting in Detroit, a paper entitled Comparison of Ideal and Commercial Carbureters was presented by C. S. Kegerreis, of Purdue University. The following is a summary of the material contained in this paper, which will be printed in full in the March issue of THE JOURNAL.

DESIRED CHARACTERISTICS

(1) The engine must develop maximum power at wide-open throttle
(2) Maximum efficiency must be maintained wherever possible
(3) Proper acceleration must be provided when using economical mixtures

CAR CARBURETION-REQUIREMENTS

(4) Vaporization and distribution must be correct in all cases


J. W. SWAN


C. S. KEGERREIS

(5) Each car has its individual mixture requirements, but the average requirements of each car-class will suffice in a practical way
(6) An average of the cars of the 1¼-in.-carbureter class requires nearly the same mixtures at the lower flow-rates as those of the 1-in.-carbureter class. The variation is mainly that slightly richer mixtures are required at the same flow-rates. The 1½-in. class is 7 per cent richer at certain lower flow-rates.
(7) A straight-line mixture does not suffice for level-road performance

COMMERCIAL-CARBURETER TESTS

(8) Carbureter-test plant and four-cylinder-engine conditions show the same characteristic metering results. The actual value of the mixture will check in most cases, but some types do not check on comparison
(9) The results of tests show that 4 carbureters out of 23 tested approach ideal metering-requirements. Two of them nearly fulfill the requirements
(10) Critical or breakdown points in metering may occur at any flow-rate, depending on individual-carbureter design
(11) Most devices could improve car economy materially by providing means for full-load compensation for power
(12) Better acceleration devices are necessary
(13) The constant-vacuum type of carbureter shows maximum flow for the minimum constriction. The fuel-air-proportioning type ranks second
(14) The plain-tube type, as usually designed, is found to be the most constricted
(15) Of the carbureters tested, 26 per cent should allow maximum power; 30 per cent are very constricted and cause a high loss in engine power; the remaining 44 per cent are responsible for only average power-losses
(16) The effect of the intake-air temperature upon any carbureter depends on (*a*) the type of carbureter, (*b*) the method of air-bleeding the fuel nozzle, (*c*) the design and number of fuel orifices and (*d*) the method of throttling the fuel-delivery nozzle by the use of a needle-valve
(17) An increase in the air temperature usually causes an enrichment of the mixture. The variables involved permit no definite statement as to the effect on all types, the variation being approximately from 5 to 15 per cent enrichment per 100 deg. for ordinary conditions

CARBURETER DATA APPLIED TO A CAR

(18) The normal carbureter as built and applied to cars will show the best economy at a car speed of about 20 to 30 m.p.h.
(19) The computed ideal mileage decreases with an increase of the car speed
(20) When all carbureters are adjusted for performance, a fuel loss of 26 per cent is shown at a car speed of from 15 to 20 m.p.h. At 25 to 30 m.p.h., the loss is also 26 per cent; at 35 to 40 m.p.h., it is about 30 per cent

The second paper of the session as given by A. M. Dean under the title Fundamental Improvements in Manifold Design is printed in this issue of THE JOURNAL, beginning on p. 139. The subject material of these contributions is worthy of very careful study.

Both papers elicited much interesting discussion which is abstracted very briefly below. In view of the interest shown by those in attendance, Dr. H. C. Dickinson, Chairman of the session, found it necessary to extend the time for discussion until 6 o'clock.

Discussion of Mr. Kegerreis' Paper

Mr. Kegerreis classified the three general types of carbureter covered by his paper as (*a*) the plain-tube type that has no moving part, (*b*) the constant-vacuum type that has an air-valve and (*c*) the fuel-air-proportioning type that is slightly different from the second in that the air-valve is not actuated entirely by the body-vacuum. Other types of carbureter can usually be classified under these three heads.

O. C. Berry stated that the carbureter maker is forced to give the automotive engineer the type of carbureter he wants, whether it be the right one or not; the type desired in turn being determined by what the competitor plans to buy. He thought those interested should make it a point to study such material as that presented by Mr. Kegerreis. In concluding his remarks Mr. Berry stated that the finger of scorn should not be pointed at the carbureter but rather at the manifold. To bear this out he described carbureter tests on single-cylinder engines when the distribution was perfect, followed by comparative tests on multi-cylinder engines to show the effect of the manifolding. These experiments were said to indicate that improper manifolding and distribution are responsible in a large measure for poor performance.

P. S. Tice felt that not all the responsibility should be laid at the door of the manifold. He called attention to the importance of effects in the carbureter metering that are due to variations in the discharge coefficient of the nozzle with changes in the temperature. His experiments and development were reported to have reduced the temperature effect greatly, so that it is now possible to retain any one of the desired coefficient curves with a temperature variation of only 2 per cent between the temperatures of 0 and 56 deg. cent. (32 deg. and 132.8 deg. fahr.). This has been accomplished by putting the orifices in series; it is found that as the number of orifices is increased, as a greater and greater slope of the coefficient curve is given, the approach to a zero coefficient is still retained. In conclusion, Mr. Tice gave a brief discussion of heat application to the manifold and stated that the design and construction of carbureters must be dependent upon the cost; certain features cannot be brought out because of added expense.

C. F. Scott raised the question of the advisability of providing for manual adjustment of the needle-valve from the dash-board. Mr. Kegerreis replied that opinions differ on that point and that the reasons for this difference are valid.

Others who discussed Mr. Kegerreis' paper were C. W. McKinley, F. E. Moskovics and F. C. Mock. The question of heat application as related to detonation was brought up and several members recalled their experiences in this connection.

A vote of thanks was accorded to Mr. Kegerreis and to Purdue University for the paper, and for the splendid research work which has been accomplished. It was also voted as the sense of the meeting that further reports are anticipated with pleasure and that the tests should be continued.

Discussion of Mr. Dean's Paper

In answer to Roy Harroun's question, Mr. Dean stated that he had made many tests both with and without controlled heat and that no detrimental effect had been noted from the application of fixed heat just above the throttle of the carbureter, provided that the jacket was not too long. However, it seemed important that this heat be not excessive. It was shown that the proper application of a certain amount of fixed heat is wholly automatic, that is, the maximum temperature is reached at low speeds and the minimum at high speeds.

Mr. Moskovics gave an interesting account of carbureter and manifold practice in several well-known racing cars. A case of vibration was described in which the difficulty was traced to unequal non-uniform compression in the cylinders.

Answering D. P. Molony's question, Mr. Dean stated that the question of hot-spotting can be solved best in cooperation with the carbureter engineers. He believed the practice of heating to be advantageous with certain carbureters. Mr. Molony emphasized the importance of suitable application of controlled heat so that the engine will give good performance in both winter and summer.

W. G. Heginbottom called attention to the fact that the point of maximum refrigeration is at the throttle or just above it. In answer to his query as to why this would not be the proper point for heat application, Mr. Dean said that it would be difficult to prevent the heat from reaching the jets, with very bad effect. He stated that it becomes necessary to strike a compromise in this respect.

C. H. Taylor's question about the effect of roughness of the inside surface of the manifold was answered to the effect that the surface should be as smooth as possible. Mr. Dean spoke of a manifold made of brass tubing with a square section and very smooth surfaces; its performance was characterized by the absence of liquid fuel and its immediate response in starting and stopping.

F. W. Burger's question brought out the fact that the mixture velocity in the Swan manifold follows the average practice closely, but that the sharp turns present somewhat of an obstruction. Mr. Dean stated further that fuel mixtures, not air, were being distributed. The claim of increased horsepower is not made by the manifold makers, but it is claimed that better starting, especially under cold conditions, better economy and increased torque through the lower range can be attained with the square section and sharp turns.

C. S. Pelton told of his experience with the Swan manifold to show that one criterion of good manifolding is the quick response in all cylinders of an engine to the cut-off of fuel-supply by leaning the dash-control of the carbureter. Mr. Berry agreed with this conception.

R. F. Kohr, O. M. Burkhardt and J. H. Holloway also participated in the discussion and brought out numerous important points. Mr. Swan replied to several of the questions. In addition to the verbal discussion, a written contribution was submitted by Prof. F. H. Vose, of the Case School of Applied Science.

THE MOTOR TRUCK AND THE RAILROADS

Coordination of Motor-Truck and Railroad Transportation for Freight Handling

After having convened the Motor-Truck Transportation Session on the afternoon of Jan. 23, Chairman F. C. Horner outlined what the Society is trying to accomplish toward the satisfactory application of the commercial motor-vehicle.

He said in part that it is particularly important that automotive engineers find out how commercial motor-vehicles should be applied, scientifically, so that waste effort can be eliminated and the way be shown to fit in each one of the various facilities where it belongs. To this end the Chamber of Commerce of the United States of America, through its Committee No. 4, made a most comprehensive report covering the Relation of Highways and Motor Transport to Other Transportation Agencies, which is printed in pamphlet form under date of Nov. 2, 1923.

In using the term "commercial motor-vehicle," Mr. Horner

Robert C. Wright

O. G. Finlay

stated that he includes the motor truck and the motorbus; that is, freight and passenger-carrying motor-vehicles that travel over highways. He said also that the importance of the work done by Committee No. 4 should be realized by everyone connected with the automotive industry; and, in line with this, that the speakers would base their remarks upon the recommendations made in the Committee's report.

Address of Robert C. Wright

Basing his subject matter upon the conclusions of Committee No. 4 of the Chamber of Commerce of the United States of America, Robert C. Wright, general traffic manager of the Pennsylvania Railroad System and a member of the above-named Committee, said that these conclusions were confirmed by the whole Transportation Conference held in the City of Washington, Jan. 11, 1924. Further, that it has become apparent that there is a "field" of transportation in which the motor vehicle will prove to be the economic transportation machine. But the definite limitations of this field cannot be determined fully until motor-vehicle transporters over the highways are charged with all proper common-carrier responsibilities, taxation and regulation, commensurate with the privileges they enjoy in the use of the public highways.

Study of the whole problem by the railroads has been directed toward determining in what definite manner the motor truck could be taken into partnership and how a start could be made. The Pennsylvania Railroad System reached the conclusions that there are three branches of rail operation with which the motor truck could be co-ordinated effectively, all of which would naturally be combined into a final plan and each of which, on the other hand, could be undertaken independently of the others so that each would progress as the situation developed in a practical way.

The three activities just mentioned are (*a*) the utilization of motor trucks in substitution for steam-railroad transportation for the handling of short-haul less-than-carload traffic, (*b*) the motorization of terminals and (*c*) door-to-door delivery-service. Mr. Wright defined short-haul less-than-carload traffic to mean small lots of freight which, under the tariffs, are loaded and unloaded by the carrier and transported for a distance up to, say, 25 or 30 miles.

The ordinary railroad method of transporting less-than-carload freight requires eight handlings; by motor truck only two handlings are necessary. But since it is not practicable for the railroads to abandon less-than-carload freight-traffic absolutely, they must continue this service and benefit at the same time by such economies as may accrue through the utilization of motor trucks.

A concrete example of an experiment that the Pennsylvania Railroad System is now undertaking in connection with activity (*a*) was given in detail by Mr. Wright. This is a combined railroad and motor-truck service. Its results so far have been

(1) The elimination of the local way-freight train, with a saving of the out-of-pocket cost for its operation, as well as of its interference with other rail movements over that part of the division

(2) Substitution of a more adjustable factor of transportation, with an immediate moderate saving referred to in item (1)

(3) A reduced number of handlings of the freight and consequent saving in loss and damage

(4) More prompt and satisfactory movement of the less-than-carload traffic

This experiment is being conducted in several districts by the Pennsylvania Railroad, and Mr. Wright said that undoubtedly it will be extended as it proves practicable and economical.

Regarding activity (*b*), a great amount of movement takes place in and around railroad terminals after the freight cars have reached the receiving yard, inbound, and before they can be dispatched from the forwarding yard, outbound. It seems desirable, therefore, to Mr. Wright to have all less-than-carload freight destined for some certain city unloaded at one properly constructed station in immediate proximity to the receiving yard and distributed from that point by motor truck to the various stations located throughout the business district; conversely, to pick-up all such freight from the last-named stations by motor truck and deliver it to the first-named station for outbound loading.

The advantages of such a plan for activity (*b*) were detailed by Mr. Wright, but he said it is a very serious problem and involves such a large initial outlay that it has been impracticable to make a start in carrying it out.

Concerning activity (*c*), "door-to-door delivery-service" is defined as being a combination of the railroad with the motor truck in performing a rail-and-motor less-than-carload freight-service from the door of the shipper to the door of the consignee. Mr. Wright said that the railroad students of this problem believe that such a service should be undertaken by a separate company and not by the railroad itself, which separate company would contract with the "traders" and be responsible for the transportation, simply utilizing the rail carrier from station to station under a proper contract. Such a rail-and-motor line would need to be a common carrier and assume all of the duties and responsibilities of such under the law. This service could not be forced upon the public; it would need to be sold to it. But those interested are convinced that a real need would be supplied and that its utilization by the shipping public would follow to a material extent.

Mr. Wright believes that activity (*b*) should not be tied together with activity (*c*), although he said others differ from him on this point. He summarized by saying: First, determine the "field" of the motor vehicle and require it to assume all the responsibilities that go with the privileges it enjoys; second, coordinate railroad, electric-line and motor-truck transportation, each serving its particular field and avoiding competition by one field with some other. Such competition never benefits the public truly; it is wasteful and, in the end, is expensive to the users of transportation.

Some of the important features of the discussion following Mr. Wright's paper are included here as being indicative of its trend. Answering P. D. Findlay, he said 32 miles is the longest haul the Pennsylvania makes of less-than-carload freight with motor trucks. Further questioning by Mr. Findlay brought out Mr. Wright's statement that the final turnover to the motor truck of the movement of short-haul less-than-carload traffic must be by degrees, until the motor truck becomes responsible as a common carrier; and that, for a local shipment just outside of say Philadelphia for a point 30 miles up the line, a motor truck would pick it up and carry it to a destination station for car shipment.

G. T. Carlin, general manager of the American Railway Express Co. in Cleveland, spoke in place of L. R. Gwyn of that company. He said the door-to-door delivery system requires almost endless study. With reference to express and less-than-carload freight conditions in Cleveland, where 7 railroads have 15 terminals, the express company there issues as many receipts as all of the railroads issue for less-than-carload freight. The explanation lies in the weight per shipment; 82 lb. per shipment for express and 656 lb. per shipment for less-than-carload freight, the latter being eight times the former. To illustrate the magnitude of the problem of door-to-door delivery, Mr. Carlin stated that the express company now has 150 motor trucks to handle Cleveland express matter but that 1200 motor trucks would be needed on the above-specified basis to make a door-to-door pick-up and delivery of Cleveland less-than-carload freight, representing a total investment of approximately $8,600,000 for trucks and garage facilities. Chairman Horner then remarked that the men who have been studying door-to-door delivery think of utilizing the available motor equipment at present in use through organization, rather than by setting-up entirely new organizations with new equipment.

J. F. Murphy described some of the features of door-to-door delivery in St. Louis practiced by the company he rep-

resents. As an instance of the relief of street congestion, this company now has 200 motor-vehicles in service; 6 years ago it had 600 horse-drawn vehicles in service. He believes door-to-door delivery must be optional and that the idea must be sold to the merchants.

Satisfactory service was mentioned by C. R. Scharff as being most desirable. Today, he said, the ordinary consumer orders far in advance if shipment is to be by less-than-carload freight, because he has no accurate idea as to when the shipment will reach him. He said further that any approximately guaranteed service on less-than-carload freight shipments would inaugurate a new era in transportation. To this Mr. Wright replied that the Pennsylvania Railroad is trying to accomplish this; that for door-to-door service the railroad need only carry freight from the outskirts of one city to the outskirts of another, thus eliminating the time required to go through the congested down-town districts. He stated too that what the railroad companies expect to do is not to pay part of the drayage but to make-up to the rail-motor line the difference between drayage from the outlying station and draying from the down-town station. Chairman Horner emphasized that dependable service is of the greatest importance.

M. C. Horine said that, notwithstanding Mr. Carlin's comparison of the 150 present express trucks in Cleveland with the possible 1200 trucks required, he thought 2-ton trucks will not be used; in his opinion the solution lies in the use of trucks of 5-ton capacity and upward.

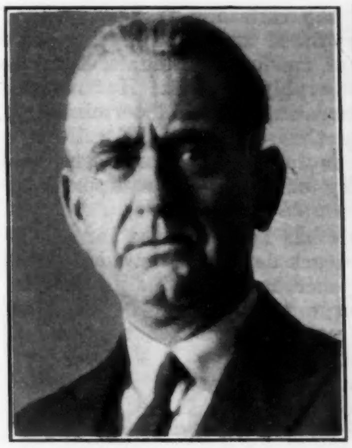
R. E. Plimpton, John Younger and others originated discussion regarding the system of motor-truck control practised by the Pennsylvania Railroad, whether the railroads are trying to limit the maximum range of the motor truck to a certain number of miles, regarding the possible transferring of the responsibility on the salesmen of motor-vehicles to some organization that would sell transportation rather than motor trucks, and matters of like nature; but the replies were in too great detail for publication at this time. As Chairman Horner remarked, "We cannot consider this subject as all black or all white; there are shades of color to it."

LESS-THAN-CARLOAD FREIGHT

How St. Louis Utilizes Motor Trucks for Pick-Up and Store-Door Delivery

This most interesting subject was covered at length in the paper R. D. Sangster, industrial commissioner of the St. Louis Chamber of Commerce, presented at the Transportation Session held on Jan. 23. In its introduction Mr. Sangster said that the St. Louis situation embraces all of the usual forms of handling merchandise in terminal cities. However, it is distinguished by a system of off-track freight-stations located at convenient points in the business districts and a fleet of tractors and semi-trailers owned by private transfer-companies, but principally by one such company, through whose facilities a large portion of the local and of the through less-than-carload tonnage is handled. The transfer companies act as agents of the railroads. In addition to the foregoing off-track facilities, a universal freight-house, to and from which the freight of Eastern railroad lines is handled in "trap" freight-cars, is operated by the Terminal Railroad Association and is used jointly by many of the railroads entering the city. The relative popularity of these two systems with the shipping public is indicated by the fact that the latter agency handles about 3 per cent only of the tonnage originating within the city limits of St. Louis.

Mr. Sangster said that, following a 2-year study, the Engineers' Committee of the St. Louis and the East St. Louis Chambers of Commerce recommended in March, 1922, against increasing the capacity of on-track freight-stations and advocated that the present system of universal off-track freight-stations of the transfer companies be extended and enlarged; and that additional off-track freight-stations be built at locations where the quantity of freight is sufficient to justify them. He believes that the St. Louis facilities are ideal as a basis for establishing store-door delivery. The system is geared closely to the actual operations of the carrier and the consignee. It is well established, has all the machinery for performing and does perform, not only the manual labor but all clerical accounting incident to handling of freight between freight-house and consignee's premises.


R. D. Sangster


J. F. Murphy

The Interstate Commerce Commission reviewed the St. Louis system in a formal proceeding and found that:

(1) The Eastern and other lines have made use of the services of the transfer companies instead of using the facilities of the St. Louis Terminal Association between East St. Louis and St. Louis, because it enabled them to handle their inbound and outbound traffic with less delay and with greater convenience

(2) Although the Western lines have rail depots of their own in St. Louis, many, if not all, of them have made similar arrangements with the transfer companies, under which conditions the off-track stations of the Eastern lines have become also the freight stations of the Western lines

(3) The operation of "off-track" freight-stations by certain transfer companies in St. Louis as public freight-stations of the carriers is found not to be unlawful or to result in discriminations that are undue

Since then, the powers of the Interstate Commerce Commission have been increased extensively by the 1920 Transportation Act, over service as well as charges and practices of interstate commerce-carriers, and new provisions in the law relate directly to the use and operation of terminal facilities. Therefore, the Commission is now in a position to require the establishment of store-door delivery.

With regard to the relation of the highways and motor-truck transportation to other transportation agencies, Mr. Sangster quoted from the report of Committee No. 4 of the Chamber of Commerce of the United States of America its findings to the effect that transportation congestion centers around railroad terminals in the large cities, that store-door delivery would relieve this congestion and increase the capacity of freight-stations, that such a system would perhaps be the greatest contribution to the solution of the terminal problem and that it would increase the load-capacity of vehicles, reduce the number of vehicles on the streets, speed-up traffic and minimize the danger to pedestrians. Further, that the charges for organized cartage should be borne by the traders as they are now, but should be less than the present cost of unorganized cartage and still should be sufficient to produce a fair profit for the cartage organization, and should be covered by separate tariff rates, and that such rates should be uniform within certain zones in the terminal area.

With reference to store-door delivery, it is Mr. Sangster's

opinion that the capacity of the railroads as a whole has not kept pace with the growth of traffic; and that, due primarily to the congestion of railroad terminals, freight-transportation is slow and car supply is short. He analyzed at length the methods of operating railroad terminals to show that these methods are the source of the railroads' incapacity. What is needed is to demonstrate more completely the organized efficiency of motorized equipment in this service.

Such congestion of terminals has been relieved largely in St. Louis by the system of off-track depots already described, wherein is concentrated the merchandise of all shippers, which is consolidated into large units up to 10 tons for delivery to the carrier; the method minimizes the moving from depot to depot of the same unit.

Railroad freight-houses should be converted from storage receptacles into facilities for clearing, in an unbroken stream, less-than-carload merchandise at its origin and at its destination. The road to that result lies in the railroads taking hold of and revising the methods of discharging and receiving less-than-carload freight, through these facilities, by consolidation of the service into fewer hands and larger tonnage units. The proper type of facility and method of operation are questions to be settled by the broader interests of the entire community and all carriers that serve it, patterned to meet local conditions in each instance.

In conclusion, Mr. Sangster outlined the report made on March 30, 1918, by Commissioner James S. Harlan of the Interstate Commerce Commission. In that report the Commissioner recognized and declared publicly that the dispostion of less-than-carload merchandise by the store-door-delivery system promised greater relief for the glutted conditions of pier stations and for the confusion of cartage operations upon Manhattan Island, New York City, than did any other plan. The report demonstrated also that store-door delivery and the terminal handling of freight are local matters. Mr. Sangster asserted that it appears clearly that the principle of store-door delivery is sound, practicable and worthy of a trial for the relief of city terminals and as a preventive of terminal congestion. The burden of proof, therefore, should be upon the railroads and all other related factors that would longer withhold from the general public such an efficacious system.

John Younger asked whether the railroads might not well liquidate some of their centrally located freight city-terminals and build terminals in outlying districts. Mr. Sangster replied that a number of railroads are doing that now in the larger cities.

M. C. Horine inquired whether it would be to the best interests of all concerned if the restrictions now in force on motor vehicles throughout Ohio on all highways were removed. Mr. Sangster said he was not familiar with the details of the restrictions, but that he thought that the communities must relieve the railroads, that the matter is a community problem and that the communities must give financial assistance where this is needed by providing traffic highways over which heavier motorized units can be operated with great economy.

L. S. Horton expressed the opinion that a proper demonstration of a suitable kind and size of container for moving freight from terminal to store-door or from terminal to terminal would give the true answer to the problem in any city.

Chairman Horner quoted an English highway engineer as having said of conditions in England, "We ought to build the roads to withstand any traffic that it is economical to handle by motor vehicle over those roads."

C. M. Manly referred to the terrific and increasing cost of doing business with inadequate facilities and said that adequate ones would be no more expensive than the way business is being done now. He believes the public shortly will demand a more efficient use of the streets in cities, if for no other reason, to prevent the enormous losses that are likely in such cities as New York due to danger of a conflagration from fires that gain headway because the fire apparatus is prevented by the congested traffic from moving rapidly enough when responding to fire alarms.

Chairman Horner concurred in this view and stated that traffic congestion can be reduced by attaining a high load-efficiency on the present motor-vehicles.

H. W. Alden said that the industry is facing a new era in transportation and that the problems incident to this new era will be solved.

THE FIELD FOR THE MOTORCOACH

Fundamental Discussion of Design and Maintenance by Vehicle and Electric-Car Engineers

The Motorbus Session was opened by a masterly address, which is printed elsewhere in this issue of THE JOURNAL, on the Field and the Future of the Motorbus by J. A. Emery, a railroad economist of wide experience. Chairman A. F. Masury expressed the gratification of the members at being permitted to hear what Mr. Emery had to say from the standpoints of the steam and the electric railway interests.

Mr. Emery said that there is great need for the motorbus, or motorcoach, to use a term that is being more widely used. Forty thousand buses, of all kinds and in all sorts of condition, have been used in the last few years; reaching territory the railways cannot reach and serving as adjuncts to and substitutes for railways.

The field of the steam and the electric railways is limited by capital considerations. There is nearly 3,000,000 miles of highways in this Country, of which 400,000 miles is surfaced. The rate of railway construction has decreased. About 2700 miles have been built since 1910. Little additional line has been built since 1915. There is an actual decrease in mileage at this time, whereas to maintain the former ratio of mileage to population 33,000 additional miles would have to be constructed.

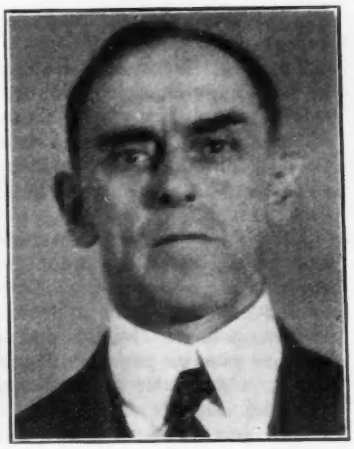
The real traffic problem now is at the terminals. An electric railway will not pay in territory having a population of less than 1500 per mile. On the other hand, a bus line can be operated satisfactorily with 1-hr. headway through districts having a population of 250 per mile. There is a tremendous field that cannot be served by electric railways. Those living within ½ mile of a bus line are prospective customers, as well as people residing in the Country a greater distance from the line. The bus cuts down the time necessary to reach the railway and triples the possibilities of the latter's revenue. The railways can well afford to subsidize such feeders. One hundred and twenty-one railways are now operating or have on order 1200 buses.

There is 45,000 miles of electric railway in the United States. Mr. Emery said that much of this should never have been built. Not half of the total mileage is profitable. With good tracks, electric-cars can be operated as cheaply as buses. With the coming of the necessity for track replacement, the bus will supplant considerable electric-line mileage.

With reference to mass transportation, Mr. Emery is of the opinion that after a certain density of traffic is reached, it must be handled by the railway as at present. But, if the bus had the same capacity and economy of operation as the trolley-car, one would be as good as the other. There is not much difference now in the cost of operation of a single-deck bus and a one-man trolley-car; or of a two-deck bus and a standard trolley-car. The great difference is in fixed charges. At Newburgh, N. Y., and Everett, Wash., bus operation has been maintained satisfactorily as a complete substitute for trolley-car operation.

The modern bus, Mr. Emery stated, must be comfortable, have a good appearance, be of adequate capacity and have good durability. The bus industry must develop reliable service. The bus is in its infancy. Designers have not really had a chance to study the problems involved. The rewards to be had for improvements in buses will attract the necessary talent. The occupation of the wide field that is available for buses will depend upon the degree of efficiency that shall be attained in their design and operation. F. C. Horner said that in England 35,000 buses carry as many people per year as 50,000 buses carry in this Country.

F. C. Horner



J. A. Emery

Among those taking part in the discussion were H. W. Alden, A. J. Scaife, M. C. Horine, Cornelius T. Myers, and R. E. Plimpton.

F. C. Horner presented, in the absence of the author, a summary of the paper on Motorbus Design, Operation and Maintenance, by R. W. Meade. In this paper, which will be found elsewhere in this issue of THE JOURNAL, it was stated that the double-deck bus, which originated in England due to the law requiring a seat for each passenger, had been successful wherever it had had a fair trial. When of proper type and operated properly, loading and unloading are not slower with it than with the single-deck bus.

The largest mass-transportation system in the world is operated in London with buses. The buses are overhauled after every 1400 miles of travel. The system is the most efficient in the world today.

The Fifth Avenue Coach Co. has operated buses profitably in New York City since 1907. It maintained 299 buses last year, the most of these being of 51-passenger capacity. The same equipment is in more successful operation at Detroit.

Mr. Meade stated that he expects steam to replace internal combustion as the source of power of buses, on account of the possible reduction of effort necessary on the part of the driver and the uneconomical constant running of internal-combustion engines.

V. E. Keenan, who is connected with a large electric-railway system in Rhode Island, expressed the view that the motorcoach constitutes a potential basis for a new thriving national industry. Within a few years the riding public the world over has indicated, by its patronage at a higher rate of fare, its desire to be transported by motorcoach wherever intelligent service of this kind has been provided.

Last year Mr. Keenan's company inaugurated a combination express and local service by electric-car and motorcoach. The success of this unique service has been pronounced. The route is from Providence to Olneyville, the latter being a suburban business center and a converging point for several suburban electric-car lines. There was a demand for more rapid transportation for those residing beyond Olneyville. Passing tracks in Providence had been suggested, so that local electric-cars could be passed en route, but the motorcoach to handle local traffic was considered a more economical means of accomplishing the desired result. The cost of the motorcoach equipment was no more than would have been necessary for passing tracks and overhead. Local passengers who formerly crowded aboard electric-cars have seats in motorcoaches, while suburban residents find satisfaction in the more rapid electric-cars between the business centers. In this way the company has effected an annual net economy of over $20,000. The operation has opened up a new field in coordinated services favored by all progressive street-railway companies.

In conclusion, Mr. Keenan said, Maintenance is the thing, and that the engineer who designs motorcoach equipment with little thought of standardization or lack of consideration of what the condition of his product will be 5 years after it leaves the factory is doing vast harm to the industry.

Boyd V. Evans, of the Detroit Motorbus Co., said that that company, starting in 1920 with eight buses, had operated its equipment 12,000,000 miles. It now has 163 buses. It was the first company to operate successfully 60-passenger buses. The upper deck of the buses are "semi-covered." The vehicles run from 150 to 200 miles per day regularly. Mr. Evans feels that no fundamental changes will be made in bus design but expects to see refinements that will tend to reduce maintenance costs and keep pace with the public demand for comfort. He predicted the use of engines of much higher compression.

J. C. Handy, of the Standard Oil Co. of California, described the vacuum pumps that have been installed in 1100 stations of his company, for the purpose of draining oil from the engine crankcases of cars. To take advantage of this system, cars are equipped with a copper tube running from the crankcase drain-plug to a convenient point under the hood. By the method a Ford car can be drained in from 18 to 20 sec. The oil is trapped in a glass flask calibrated in quarts.

"PRODUCTION" IN ITS MANY PHASES

Statements by Representative Production Men of Some Problems Now Uppermost

Sessions devoted to production were begun on the afternoon of Jan. 24, and continued during the morning and afternoon of Jan. 25. At the first session, K. L. Herrmann was in the chair.

Flexibility in Handling Production Material is the title of the paper that was presented at this session by A. A. Brown, stock manager of the Chandler Motor Car Co. It is printed in full elsewhere in this issue of THE JOURNAL.

Mr. Brown described a simple, elastic and practical method of handling materials effectively throughout the various units of a large automobile factory. It has been developed and extended from the early stages to cover widely separated plant-units. With elasticity as the keynote, the stockrooms are scattered; the materials are placed promiscuously throughout the plant near the places of their consumption in as large quantities as possible. Those in charge are allowed to use discretion as to the routing, and to decide which parts are to undergo thorough inspection and which can be sent directly to the points of assembling. If the needs of production demand it, material can be hurried through the inspection department or an inspection can follow it to the assembling line.

Material is transported by electric or gasoline trucks. Hand-trucking is not permitted except in otherwise inaccessible places. Gravity conveyors are used extensively. Materials are held in the stock-room. Service-department requirements are supplied directly from production stock. A perpetual inventory is not kept; it is considered that it is cumbersome and expensive, defeats its own purpose and slows-down the delivery of material.

A. A. Brown

Thomas Nadin

One function of a perpetual inventory is effected by a shortage report that is made out when notice has been received from a stock-clerk or a foreman that the quantity of any part is getting low. An advantage of low stocks is that, if changes are made in parts, the new parts can be substituted quickly without waiting for a large stock of old material to be used-up.

The only stock records kept are those of the purchasing department. The stock department has access to and assists in compiling these. Stock-chasers go over the lists each day to determine whether the material received is up to specifications, and whether a shortage is likely to arise. By carefully selecting the personnel of the material-distribution division, flexibility is capitalized and changing conditions can be met quickly.

Chairman Herrmann mentioned the small quantity of stock on hand he had observed in the Chandler plant and asked if the chief inspector has charge of the final assembly. The answer was that the foremen have charge of this.

In reply to several other brief and direct questions, statements were made that the foreman keeps no record of the amount of stock on hand in his department and depends upon observation for knowledge of low stocks, and that records of receipts and invoices are kept. The packing-slip method was described.

J. Lannen called attention to the advantage of having "pull type" men pull things through. A query as to whether machine set-ups are changed often caused Mr. Brown to say that the foreman must use his best judgment in that regard; he may be obliged to change set-ups frequently. Chairman Herrmann asked how the buying is classified and was told that this is done according to vendors; the stock-chaser has an outside connection altogether.

PRECISION MEASUREMENTS

How the Paige-Detroit Motor Car Co. Operates Its Gage-Checking Department

Accurate gaging requires not only that gages having the requisite degree of accuracy be employed, but that they be checked at frequent intervals so that their precision will be maintained. This introductory statement was made by Joseph Lannen, tool and equipment engineer of the Paige-Detroit Motor Car Co., in a paper.

As the size of the plant of the company with which he is associated increased, a constantly increasing volume of scrapped material due to the use of faulty gages developed. About 2 years ago, this matter was investigated by the engineering department of the company and a method of gage-checking was devised and installed. This method requires a means of identification for each gage, the culling out of all unused and inaccurate gages, a check-up on each gage at stated intervals and a record of the actual measured size of each gage as it is checked.

The procedure at the beginning of the installation of this system was that every gage in the plant was checked; gages that were inaccurate were eliminated; gages that were up to size were numbered, each gage of a given size being given a consecutive number; and a card was issued for each gage, showing its nominal size, its number, its proper location in the plant, its actual measured size and the date on which it was checked. Each gage was then given a thin coat of Prussian blue on the gage face and returned to circulation. Gages that were too badly worn were painted red and again put into service pending replacement by accurate gages. A gage that showed wear of 20 per cent of the tolerance specified was considered inaccurate. For instance, a 0.3750—0.3740-in. plug-gage would be replaced when the "go" member became worn below 0.3738-in. This allowance for wear proved to be satisfactory.

After the gages had been checked and numbered, a weekly check was made on all. Since those still blue had not been used, it was unnecessary to recheck them; but all are blued after each periodic check. Gages remaining blue show that a gage has not been used as specified. The gage checker reports such cases.

Later, all information relating to gages was concentrated in the gage-checking department. All undersized or obsolete gages were stored there, as well as the reserve supply of new gages. The department has standardized so far as possible on Johansson built-up plug-gages, adjustable snap-gages and thread snap-gages having interchangeable gaging members.

Repair parts for micrometers, amplifiers, dial indicators and scleroscopes are kept in stock; repairs on these are made by the department. Employes' micrometers are checked on request; company micrometers are checked periodically; scleroscopes are cleaned daily; special gages and inspection fixtures receive periodic checks and are followed-up for repairs. Gear-cutting hobs also are checked by the gage-checking department.

Two sets of record cards are used. Those already mentioned are filed under headings of gages in service, obsolete gages and salvaged gages. The other set has a card for each size of gage; these are filed according to size and type and list every part on which each gage is used. This latter record-system is used to determine the number of gages of a given size needed for production.

Checking equipment in the department consists of a surface plate; bench centers; a ground angle-plate; a square; a pair of "V"-blocks; a pair of cubes; four pairs of parallels; a height-gage; a 24-in. vernier caliper; a set of micrometers, 1 to 6 in.; a set of arbors; a set of Johansson blocks; two indicators, a sine bar and all necessary clamps and fixtures.

Mr. Lannen said that, with the foregoing equipment, two men have taken care of 1600 pieces of gaging equipment; and that, since the gage-checking department had been established, there has been no rejected work from the machine-shop on account of faulty gages.

In reply to a question regarding how gages are sent to the department for check, Mr. Lannen said that a gage-inspector goes through the plant on inspection tours and collects them. The idea of this is to keep the gage on the job by having the gage-checker go to the gage.

MACHINE-TOOL IMPROVEMENT

Desirable Practices Suggested for Their Builders and Users

Thomas Nadin, general superintendent of Rolls-Royce of America, Inc., presented a valuable paper covering the subject specified above. Its full text will be found elsewhere in this issue of THE JOURNAL.

The paper states that many machine-tools suffer from insufficient lubrication. For slow-speed intermittent work lubrication usually is through a small hole in the boss in which the shaft revolves. This is an unsuitable method for machine bearings that run constantly at medium speed. A felt pad of liberal size underneath stationary bearings, held in contact with a spring, constitutes a remedy. The type of self-oiling roller or ball-bearing commonly used on electric motors and line-shafts is a better construction.

Loose pulley and similar bearings require roller bearings for slow and medium speeds, or single-row ball-bearings for higher speeds. These must be designed carefully for use with heavy mineral oil, rather than cup-grease. Exclusion of dirt, water and the like is important.

Systems for supplying lubricant to the tool, although usually provided with pumps of sufficient size, frequently have guards and channels that are insufficient to care for the splash and the return, and a microscopic filter that soon becomes choked. On automatic machines, these sometimes are found to be unusable after 2 weeks' service. This results in the spindle bearings, the slides and the screws becoming worn because of the presence of solid matter in the cutting oil. Other points covered in the paper include tanks for

the cutting compound and the use of flexible metallic hose in preference to rubber.

W. W. Nichols discussed countershaft troubles. He said wood bushings last longer than bronze bushings. He described a metallic vacuum oil-cup that will start feeding within 2 min. when held in the hand. Its principle is that the heat of a bearing will start it feeding.

J. N. Heald described a factory he visited in Meriden, Conn., which has 20 grinding-machines in one bay driven by countershafts, and a similar set of such machines in an adjacent bay all motor-driven. The contrast in lighting-effect improvement, reduction of moving parts and the time required to supervise their oiling was startling, he said, the motor-driven machines being far superior in these respects.

Chairman Herrmann said that greasecups are suitable only for parts that do not make complete revolutions; also that oil-can lubrication is not possible at high speeds of moving parts when the clearances in the bearings are small.

J. Pflum mentioned the diffident attitude of engineers toward salesmen who bring to their attention matters of sales resistance that concern engineering features. In reply, Mr. Nadin said that very few of the recommendations from sales sources had more than very elementary merit and often had already been considered by the engineers.

Glenn Muffly endorsed what had been said about the importance of cleaning-up externals on machines, such as closing-in shafts. He believes forced-feed lubrication will be used to a much greater extent.

Regarding wood bushings, Mr. Nadin said that they are suitable for moderate loads and speeds; they are successful in some cases and not in others. The proper way to run a bearing is on an oil-film. There is no good substitute. He advocates less activity in designing ingenious feeding devices and a devotion of effort to *keep the oil in the bearings.*

HOT-SWAGING OF REAR-AXLE SHAFTS

Maxwell Executive Commends It as Best and Least Expensive Method

It is possible to reduce the cost of rear-axle drive-shafts and materially increase their strength by adopting the hot-swaging method of forming them. This is the opinion of R. A. DeVlieg, tool engineer of the Maxwell Motor Corporation, who read a valuable paper on the subject at the Friday afternoon Production Session during the Annual Meeting. Mr. DeVlieg's paper will be published in full in an early issue of THE JOURNAL but a résumé of it will be given here.

The swaging method would be the most economical and satisfactory method of producing axle shafts provided the maintenance cost on the swaging machines could be reduced. The Maxwell production staff is sure that this can be done by improving the design and construction of the machines so that frequent breakdowns resulting from excessive vibration can be reduced to practical limits. Before reaching the conclusion that hot-swaging is the most desirable method, rolling, forging in steam-hammers and turning from bar stock were tried successively in the Maxwell shops. In addition to the reduced cost, the Maxwell testing laboratories have found that the strength of the shaft is improved at least 15 per cent by the hot-swaging method.

In the Maxwell swaging machines, a heavy spindle is provided on which a heavy flywheel is mounted. The head of this spindle is formed with rectangular hole at right angles to its center-line and the two halves of the die are set into this hole. Each half of the die is backed up by a hammer block that has a roller inserted in the side opposite the face that is in contact with the die. The spindle turns at 225 r.p.m., forcing the dies to open and close as the rollers in the hammer blocks come in contact with a series of 12 rollers that are equally spaced in a cage or separator. This cage is free to rotate in a heavy hardened bushing so that the force of the blow as applied to the rollers can be distributed over the whole circumference of the head. With this arrangement, blows are struck with the dies at the rate of 2700 per min.

The opposite end of the machine is provided with a slide, operated by a star-wheel through a rack and pinion. The axle-shafts, heated to a forging heat, are held in a special chuck and fed into the dies by this star-wheel. As the shaft enters the die it has a tendency to rotate at the same speed as the head and it is necessary to restrict the speed of the head holding the shaft by a brake. If the shaft should rotate at the same speed as the head, no swaging action would take place.

Several troubles were encountered in the development of this machine. It was fitted with an air-operated collet originally but this had to be replaced with a special quick-operating chuck with high-speed steel inserts set in its jaws. The braking mechanism for slowing-down the head was inadequate and additional braking-capacity had to be provided by a copper-lined brake-band. Careful application of this brake is necessary to avoid excessive twisting of the hot axle-shaft. The tendency to twist the shafts was reduced by providing an exact amount of clearance in the dies. This was taken care of by shimming the dies with plates of varying thickness.

Rapid wear of the rollers in the head was another trouble encountered. This was overcome by filling the head with lubricating grease and changing this grease frequently. One of the most serious faults in the swaging machine was the excessive wear in the front bearing. It was lubricated with oil originally but this has since been changed to grease. This is not entirely satisfactory because it is often necessary to replace the bearing, there being no simple means of adjusting it for wear. Swaging machines should be considered as forging machines rather than machine-tools and given more attention and frequent adjustment than machine-tools. Manufacturers of swaging machinery must study the conditions met by their machines and benefit by the experience of the automotive companies that are experimenting in this field. Stresses on the component parts of the machines have been difficult to calculate or estimate and their fitness for service must be determined by practical tests in the hands of the user.

The only objectionable feature that has come to the attention of the Maxwell production department in the adoption of hot-swaging is the twisting of the axle-shaft while the hot bar is being fed into the dies. This excessive twisting is due to overheating of the stock or to carelessness on the part of the operator in applying the brake to the head. It is not unusual to find shafts twisted from one to three turns in their over-all length. Laboratory tests have shown that the elastic-limit or ultimate tensile strength of the shaft is not appreciably reduced on this account.

ENAMELING OF FENDERS AND BODIES

Equipment for Quantity Output Described—Crankshaft Production Problems Discussed

In introducing Gordon Lefebvre, who gave a paper on Process and Equipment for Fender and Body Enameling at the Production Session held on the morning of Jan. 25, John Younger, the presiding officer, called attention to the complexity of the subject. Mr. Lefebvre, after referring to the intensive study that has been made in recent years of enameling or japanning fenders, sheet-metal parts and bodies, discussed the marked improvement in the equipment with consequent simplification of the processes, better quality of product and decreased cost of labor, material and fuel. Fender and body enameling departments are now the cleanest, most comfortable and least dangerous parts of the plant.

The paper, which is printed elsewhere in this issue of THE JOURNAL, was limited to treatment of improvements made in mechanical equipment and the processes employed in the car-

assembly plants of the Chevrolet Motor Co. It is not felt that even now the methods are satisfactory.

Enameling of the parts under discussion involves the application of two coats of asphaltic-base enamel and a subsequent baking at about 450 deg. fahr., and in the case of bodies the application of three coats with baking at from 290 to 350 deg. fahr.

The main topics of the paper were: inspection of raw material, location of equipment and stock storage, preparation of metal for enameling, types of fender and body enameling ovens, oven-wall design, conveyors, paint-handling equipment, oven heating and temperature control, fire prevention, cleanliness and handling of finished enameled parts.

The grade of sheet specified for fender stock is full-pickled, full cold-rolled and re-annealed sheet steel, fender and hood grade. In view of the few coats of enamel applied, it is essential that the sheet stock be of the best grade. The sheet mills should be more familiar with the needs of motor-car builders in this respect.

A summary could hardly do justice to the paper because it consists of categorical accounts of the different methods and apparatus that have been tried and developed by the Company. Suffice it to say that comprehensive information is given on the topics listed above. No one interested in this line of work can afford not to study the paper carefully.

The cleaning of the bodies as they come from the body-building department is a comparatively simple matter. Gasoline of relatively low volatility is now used for this purpose in much larger proportion than formerly. The ovens, of the semi-continuous type, are built on the roof of the factory. The production is 28 bodies per hour.

John McGeorge brought up, among other subjects, the matter of conveyor-chain pulsation or vibration, which he said is difficult to eliminate and should be studied. Chains, supposed to be exactly alike, running side by side, do not perform alike.

In reply to a question, Mr. Lefebvre said that subjecting the wood in a body to a temperature of 300 deg. fahr. for 1 hr. has no bad effect on it. A separate oven is provided for enameling gasoline tanks at 275 deg. fahr. for 2 hr.

The Machining of Crankshafts

T. M. Carpenter outlined the practice of machining automobile crankshafts and the troubles encountered and the remedies applied. He listed 10 routine operations on the shaft, beginning with roughing and ending with inspection. Forgings are straightened and centered on a special indicating machine. Following the rough-turning, the center bearing is ground. All thrust dimensions are taken from the center bearing; this tends to reduce cumulative errors. Stock is removed at the rate of 3.14 cu. in. per min. per machine. The pins are rough-ground to within 0.25 in. of finished size. In drilling force-feed lubricating holes, hand-feed drills are preferred. Power-feed drilling involves more drill breakage.

A preliminary static-balancing operation is conducted. The crankpins are then finish-ground. The use of force-feed lubrication has required closer limits on the length of crankpin bearings.

The next phase of the procedure is the secondary lathe operations. The necessity for great accuracy in both the size and the location of flange holes makes it advisable to defer the operations required until they can be done most advantageously. The same thing applies to keyways.

After all machining operations, the shafts are balanced dynamically or statically as required, to correct unbalance caused by machining after the preliminary balancing.

Glenn Muffly suggested that balancing the shaft statically first increases the difficulty of balancing it dynamically and that when the dynamic balance is secured first the static balance is taken care of.

H. M. Crane said that static balance may improve the condition for dynamic balance. If this is not the case, it is futile to balance statically first. If the forgings are good enough, it may not be necessary to rough-grind before balancing dynamically. Full advantage is not taken of a six-cylinder crankshaft unless it is balanced dynamically.

Chairman Younger referred to certain articles that had been published in the *American Machinist* in regard to needed improvement in the shops of the automotive industry. F. H. Colvin of that periodical said that the automotive shops are the best in the Country but are not "100 per cent."

K. T. Keller made a plea against operating on a smattering of knowledge. He said that too many men in responsible positions are not honest with themselves. The automotive industry is young and should and is bound to improve. He pointed out that Mr. Lefebvre in his paper had related experiences, particularly about things that did not work. Many spend much on "cureалls." If they would scan the experience of others, they would find that not much is new. Eternal vigilance is necessary.

The reason crankshafts are not balanced dynamically is that there is no machine that will balance them quickly. Of course, a shaft can be balanced at a certain cost. This must be paid for.

CUT RED TAPE TO REDUCE COSTS

Production Session Speaker Favors Directness of Military Organization Plan

Reduction in costs is uppermost in the mind of every automotive engineering executive today. Therefore, it was reasonable to expect that keen interest would be shown in the talk by Edward H. Tingley, assistant superintendent of the Delco-Light Co., at the Friday afternoon Production Session when he discussed Reducing Costs by Efficient Management. Favoring the directness of the military type of organization and recommending a minimum of departments and executives, Mr. Tingley struck a responsive note when it was seen that he was an enemy of over-organization and red tape.

Two important considerations are to be emphasized in studying any organization; first, the organization and personnel; and second, the control of finances, operations and sales by a budget system. The selection of personnel is a most important matter. It is not logical to have a business follow a definite organization chart when it is considered that all men have their own methods of operation, their own methods of thinking and their own personalities. The organization chart should be suited to the type of men available, to the product that is to be made and to the scale of production. Each man should be fitted to his proper place, both by training and by according him sufficient responsibility to handle the job to which he is assigned.

Over-Organization Should Be Avoided

Military organization has proved itself best in a fight. After all, is not business a fight from day to day? It is very keen competition, especially at the present time. The military form of organization demands a definite segregation of responsibility. There is no over-organization; likewise, there is no under-organization. There are just enough men for the duties to be performed and no extra men are standing around impeding the work of others in the fighting unit. There is little value in having unnecessary executives when it is realized that they represent overhead which in turn represent increased production cost. It is just as dangerous to be under-organized; lack of proper records and lack of system and methods will very materially decrease efficiency and increase costs.

It is Mr. Tingley's opinion that there are four divisions of a business and that there need be no more. The general manager is the general of the military organization. He has under him four divisions; first, the engineering division which is responsible to design the product and furnish the factory with the necessary drawings and specifications; second, the sales division which is responsible to find a market for the product and sell it; third, the finance division which is responsible to provide the necessary funds for material, equipment and capital to operate the business; fourth, the manufacturing division which is responsible to make the product and put it in the warehouse ready for sale. The

general manager should be in a position to check the operation of these four divisions readily. He can tell from public opinion whether the design of the product is satisfactory and that is his check on the engineering division. The volume of sales will serve to check the efficiency of the sales division. Inspection of the product and the record of material delivered will check the efficacy of the manufacturing division. The check on the efficiency of the financial division is made through the auditor who approves the financial records. Mr. Tingley separated each of these main divisions into its smaller parts and indicated how all the minor details could be grouped under one of these four heads.

Material Largest Cost Factor

Analysis of the Delco-Light Co.'s operations has shown that approximately 52 per cent of the production cost is represented by the cost of materials. This indicates how essential it is to keep a check on the purchasing department if costs are to be reduced. Labor cost is in the neighborhood of only 9 per cent, showing how futile it is to expect any appreciable reductions in production costs by the reduced wage route. Overhead represents a very large percentage of the total cost of any product and it is not always combed as finely as it might be to effect cost reductions.

Definite budget expenditures are allocated to each of the divisions of the Delco-Light Co. for each month and year. It is the business of the executives in charge of these divisions to see that the required work is done within the budget figures that have been set to yield a reasonable percentage of profit on the invested capital. If each division lives up to its budget, the financial success of the entire producing unit is assured. The sales division is expected to analyze the market and make a fairly accurate estimate of what can be sold. Often the sales department is given a larger quota than the manufacturing department, enabling the latter department to work along conservatively, following the sales close enough to meet all delivery demands without maintaining a large inventory in the warehouse. When an organization is trimmed to the bone, its executives are stripped for the commercial fight. Red tape disappears and reduced costs are bound to result because each man recognizes his definite responsibility to secure the ultimate profit.

Purchasing a Manufacturing Division Function

Questions asked during the discussion brought out many interesting points. Mr. Tingley said that the Delco-Light Co. places the purchasing department under the control of the manufacturing division. Material shortages, poor materials and delayed materials are problems always present in all organizations. They are the problems of the manufacturing division because this division is charged with the fabrication of the product from these materials. Delco-Light considers shipping as a function of the manufacturing division. It is also its contention that the foreman should be supreme in his own department and should do the hiring of his helpers. An employment department serves to sift the good applicants from the bad, but the foreman is held responsible to get results and should be accorded the privilege of selecting his personnel. Carrying the principle farther, the foreman should be authorized to dismiss a man from his department. This does not mean that he can dismiss him from the company's employ for the man must first be interviewed by the employment department with regard to his being qualified to perform some other class of work in another department.

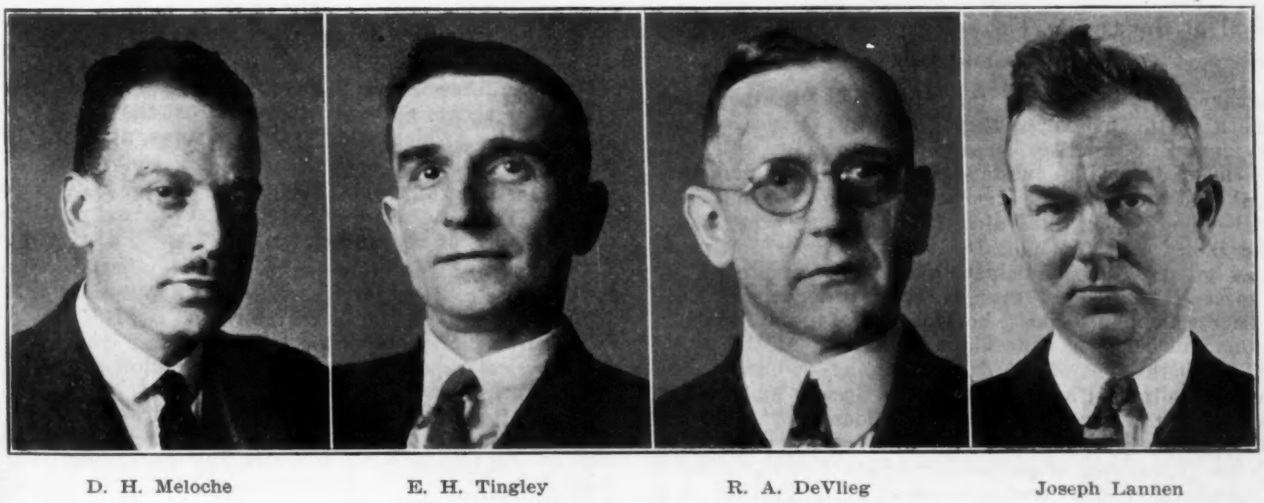
Asked whether the engineering department could be placed under the supervision of the manufacturing division, Mr. Tingley replied that it depended entirely upon the type of product manufactured and the scale of production. He intimated that this could only be done in special cases where the personnel was peculiarly qualified to insure the success of this unconventional arrangement. Inspection in the Delco-Light organization is under the direction of the general manager on the theory that he is directly responsible to the directors for a product that will meet with public approval and result in financial success for the company. He settles all controversies that may arise when the engineering division demands a degree of accuracy that the manufacturing division considers impracticable.

CASTING IN LONG-LIFE MOLDS

New Development in Successful Use Is Described at Production Session

Foundrymen have always felt that the destruction of the mold every time a casting is poured is a decidedly inefficient procedure. It would be ideal if someone could develop a permanent-mold method of casting and many attempts have been made in this direction. One scheme that has been used successfully for 2 years was described by Daniel Meloche at one of the Production Sessions in Detroit at the time of the Annual Meeting. Mr. Meloche said in part:

> The following conditions would seem to be indicated in developing a mold of the "permanent" type: First, the mold surface must be of a highly refractory character so that the least possible heat may be transmitted inward to affect the form of the mold as well as seriously limit the rate of pouring iron for castings into it. Again, a too hot mold will warp and deteriorate rapidly. Hence the desirability of having the



D. H. Meloche E. H. Tingley R. A. DeVlieg Joseph Lannen

Four Speakers at the Production Sessions

mold light and if necessary air cooled, so that the mold body temperature may be controlled. Second, the mold surfaces must be sufficiently strong to resist the cutting action of the molten metal and be impervious to the entrance of fine filaments of iron which on removal of the casting would take some of the mold material with it. Third, the mold surfaces must not spall off.

In the development described by Mr. Meloche, the primary idea has been to make a very light cast-iron mold, the surface of which is covered with a layer of highly refractory material of necessary thickness, and this refractory material protected from abrasion and penetration of fine iron filaments so that it rarely needs to be patched-up or refaced. For operating purposes, where the castings are not large, a group of molds is placed upon a revolving table and the several steps of the cycle can be carried out almost automatically.

How The Molds Are Operated

The refractory material forming the mold surface consists of two items, the refractory material itself and the binder to bind it to the iron backing. The molds are placed in their proper position on the revolving table and successively follow their prescribed course. In passing around, the two parts of the mold are drawn apart sufficiently to allow the settling of cores, but just before each mold successively passes a flame which smokes the inner surfaces heavily. The idea of this is to interpose a film of carbon, or lampblack, between the refractory surface and the molten metal of sufficient thickness to prevent effectively any scoring action or the actual contact of metal and refractory material at the instant when the greatest temperature is reached.

After passing the flame and the position where the cores are set, the two parts of the mold are closed automatically and are held thus until poured off and the metal has set sufficiently. Then they quickly open and the castings are forced out by pins. Next, a blast of air rapidly blows the surfaces clean and the mold passes before the flame again. An attendant inspects the mold surface condition as the open molds pass by and any fragment of iron or core left in the mold is easily removed with a suitable tool.

Since the iron backing of the mold is comparatively thin air-cooling action can be effected. Sometimes an air blast is used to cool the iron molds a little faster than normally and the machine can be speeded up and thus give a larger production. With 12 single molds on the revolving table, one man can pour 400 molds of a given kind per hour. With sand casting it takes eight times the number of man-hours to get an equal number of the same kind of castings.

MONKEY-DANCE A SPECTACULAR SUCCESS

Carnival at the Oriole Terrace Attended by Over 850 Members and Guests

The saxophone playing of the Six Brown Brothers and the dance of the monkeys, or perhaps we should say the monkey-dance in order to be absolutely precise, will long be remembered as the outstanding features of the 1924 Carnival held at the Oriole Terrace in Detroit. Ten o'clock found the dance floor filled almost to the saturation point, and the tables occupied indicated that well over 850 members and guests were participating in what was to be the most successful Carnival ever held by the Society. The dance floor was shaped like a horseshoe, a stage at the open end being reached by a wide flight of stairs. At the upper end and on both sides of the dance floor, as well as on two terraces concentric with it, were tables. Society and Section banners were in evidence, while over the floor were suspended more than 20 life-size, as well as life-like, toy monkeys.

With the appearance of gaily colored hats, favors, balloons of all shapes and sizes and streamers, the gathering took on the character of a Mardi Gras, which was heightened by the fact that the many excursions of the members from the tables that served as their headquarters during the evening, and also during the early morning hours, were continually interrupted by chance meetings with old and new acquaintances. At midnight the curtains on the stage were drawn together. While waiters were serving salad, ice-cream and sundry other dishes, the inimitable Brown Brothers appeared, much to the enjoyment of those present. Several dancing acts followed. The evening was well under way.

At 1 o'clock the monkeys, that is, the toy monkeys, which had hitherto remained hanging motionless above the dance floor, began to come to life and, one after the other, to dance loose-jointedly up and down until, with a wild plunge, they would disappear in a sea of upraised hands. Although there were only about 20 monkeys, there were many more than that number of winners, as the interest in the last few jungle squirrels was so great that several arms, legs and tails were found to be missing by those who were technically declared to be the winners. Without doubt, the dance gave more enjoyment to the spectators than to the dancers. Henry Ewald, who discovered the innovation, deserves the thanks of every onlooker.

George H. Hunt, the chairman of the Carnival Committee, and Fred A. Cornell, G. E. Goddard, M. P. Rumney and others deserve much credit for making the Carnival the best ever, as was evidenced by the question, asked repeatedly during the remaining sessions, "Will the Carnival be held at the Oriole Terrace next year?"

A SYMPOSIUM ON RIDING COMFORT

Its Factors Considered Informally at Supper Arranged by Research Department

The great importance of the riding-comfort problem and the increased interest devoted to it by automotive engineers prompted the Society's Research Department to invite a number of members and others known to be interested in the subject to discuss it informally at a supper held in the General Motors Building, Detroit, on Jan. 22. Dr. H. C. Dickinson acted as chairman.

In outlining the general problem Dr. Dickinson suggested the following questions as a basis for discussion:

(1) What characteristics of the motion of a vehicle are especially disagreeable to the occupants? Are the actual motions, the accelerations, that is, the forces involved, or the rates of change of these forces, of major importance?

(2) Are persons equally sensitive to motions or forces in different directions, vertical, longitudinal or transverse, and, if not, which are more important?

(3) Are passengers sensitive to the motions of the vehicle body or only to those motions or forces transmitted through the upholstery, or partly to both?

(4) Do different people have radically different characteristics as regards discomfort, that is, are motions which are pleasing to some, uncomfortable to others?

(5) Is there any practicable means of gaging the degree of discomfort attendant upon any particular type of vehicle performance?

Among those who discussed the above and other important factors were representatives of practically all branches of the industry, as well as Dr. A. E. White and Dr. R. Gesell, of the University of Michigan, who spoke on the physiological and psychological aspects of the problem. Following is a list of those in attendance:

G. B. Allen	Dodge Bros.
C. M. Aument	International Motor Co.
C. C. Blackmore	C. C. Blackmore Co.
R. S. Burnett	Society of Automotive Engineers, Inc.

S. R. Castor	H. H. Franklin Mfg. Co.
L. A. Chaminade	Studebaker Corporation of America
Herbert Chase	Class Journal Co.
C. F. Clarkson	Society of Automotive Engineers, Inc.
H. M. Crane	General Motors Corporation.
L. R. Davis	United States Rubber Co.
G. A. Delaney	Paige Motor Car Co.
H. C. Dickinson	Bureau of Standards
C. F. Drumm	International Motor Co.
Leighton Dunning	Watson Stabilator Co.
Tore Franzen	Detroit Steel Products Co.
R. Gesell	University of Michigan
J. E. Hale	Firestone Tire & Rubber Co.
George E. A. Hallett	General Motors Research Corporation
F. P. Herman	Houdaille Co.
C. A. Hogentogler	Bureau of Public Roads
W. C. Keys	Gabriel Snubber Sales & Service Co.
B. J. Lemon	United States Rubber Co.
T. J. Lítle, Jr.	Lincoln Motor Car Co.
C. M. Manly	Manly & Veal
G. J. Mead	Wright Aeronautical Corporation
R. E. Plimpton	*Bus Transportation*
H. L. Pope	Wright Aeronautical Corporation
J. C. Sproull	B. F. Goodrich Co.
L. M. Stellman	H. H. Franklin Mfg. Co.
W. R. Strickland	Cadillac Motor Car Co.
S. P. Thacher	United States Rubber Co.
J. A. C. Warner	Society of Automotive Engineers, Inc.
J. W. Watson	Watson Stabilator Co.
A. E. White	University of Michigan
C. B. Whittelsey	Hartford Rubber Works Co.
K. M. Wise	Studebaker Corporation of America
S. H. Woods	International Motor Co.

It is planned to present in an early issue of THE JOURNAL a comprehensive abstract of the very interesting discussion.

SECTIONS DINNER REFLECTS OPTIMISM

Representatives Report Flourishing Meetings and Are Confident Problems Can Be Solved

Although the Sections of the Society are facing two or three major problems, it was evident from the reports presented at the Sections Dinner during the Annual Meeting that, with one exception, the Sections are in flourishing condition. Meetings are being held regularly, attendance is better than in past years, papers are of good caliber on the average and all Sections have substantial bank-balances. The Detroit Section is making a success of its ambitious program of two meetings monthly and attracting production men to the Society. The Indiana, the Cleveland and the Mid-West Sections report increased interest in their meetings.

Collection of Section dues seems to be the problem uppermost in the minds of the Section officers. Not all members in a Section district appreciate the reasons for Section dues and pay them without persistent appeals and follow-ups. Some seem to feel privileged to attend Section meetings and secure the benefits therefrom without paying anything in addition to their national dues. It is unfair to expect less than half of the members in a district to carry the dues burden of the Section in that district, yet the Section officers find the task of convincing many of the members of this fact a burdensome one and one interfering with the efficient management of the Section's professional affairs. The need of a more equitable distribution of the Section dues burden was stressed by the representatives of nearly all the Sections.

Another important problem facing some of the Sections is the lack of a means whereby non-members of the Society may lend financial support to the Section in return for the privilege of attending its meetings and receiving its printed notices. While some of these non-members could qualify as members of the parent Society, a large majority of them do not feel able to pay the initiation fee and dues or else they are interested only in the local activities of the Society. The logical solution of this problem is the authorization of some form of local associateship similar to that provided for some years ago. This type of local participation was discontinued because some of the Section Associates had the mistaken impression that they were members of the parent Society and abused the limited privileges of their local affiliation. All are agreed that, if any new form of local associateship is authorized, its privileges must be limited and the limitations rigidly enforced.

Solutions for both of these problems are being sought by a Special Committee appointed by the Council and this Committee has conducted hearings in New York City, Dayton, Detroit, Cleveland and Indianapolis for the receiving of suggestions. The Committee is constituted of the following:

B. B. Bachman, *Chairman*

J. H. Hunt H. W. Slauson
T. J. Lítle, Jr. John Younger

The entire committee was present at the Sections Dinner.

It was evident from the reports presented at the Sections Dinner that the activity and effectiveness of a Section depends largely upon the enthusiasm and the qualifications of its officers. For this reason, all were agreed that the selection of Section officers is a matter deserving the utmost care and deliberation. Nominating committees should be selected with regard to their interest in the Section and its future; their members must appreciate fully the importance of the task assigned them and prepare their slates of officers with much more than casual judgment.

Several of the Section representatives at the Dinner recommended that some means be provided for assuring a greater continuity of officers on the Governing Committees of the Sections. They felt that men having experience in operating the Section should be carried over automatically so that their experience would be available to the new officers. It was suggested that this could be taken care of if the Nominating Committee kept the matter in mind when selecting candidates for office.

The importance of adequate and appropriate publicity as a means of building-up interest in Section meetings and securing good attendance was stressed by many of those present. The Indiana Section has done very effective work in this line and increased the average attendance at its meetings from 50 to 250, with a consequent increase in Section membership. It was recommended that professional assistance from the headquarters staff of the Society be extended, but not to the extent of dislodging the Section officers from a feeling of full responsibility for the effectiveness of their Section.

President Crane spoke briefly and assured those present that he appreciated the importance of the Sections as a major activity of the Society and intended to see that their problems were given prompt attention by the Council and the Administrative Committees. The following were present at the Sections Dinner:

S. W. Asire	L. Clayton Hill
B. B. Bachman	J. H. Hunt
O. C. Berry	W. C. Keys
George Briggs	T. J. Lítle, Jr.
W. J. Buettner	George McCain
F. F. Chandler	H. O. K. Meister
C. F. Clarkson	Cornelius T. Myers
H. M. Crane	O. A. Parker
G. W. Gilmer, Jr.	J. F. Max Patitz
G. E. Goddard	A. J. Scaife
George Hallett	A. W. Scarratt
A. W. S. Herrington	H. W. Slauson
K. L. Herrmann	George W. Smith

W. R. Strickland
J. J. Wharam
J. W. White
R. E. Wilson
C. W. Young
John Younger

HORNING DEMONSTRATES RICARDO HEAD

Factors Governing Engine Performance Discussed by Indiana Section

H. L. Horning

Combustion and heat-dissipation, distribution and economy, detonation, flame-travel and spark-advance were some of the subjects that had a hearing at the Jan. 17 session of the Indiana Section. These and other factors were brought out in a very convincing and interesting address by H. L. Horning, general manager and secretary of the Waukesha Motor Co., who outlined his "strategy" in improved engine design. The speaker prefaced his remarks with the statement that facts, not lore or tradition, should be chosen as the fundamental basis for all sound engineering. He then proceeded to discuss in detail some of the newer ideas in engine design.

The Piston

Introducing the subject of piston design, Mr. Horning called attention to the fact that the piston presents a very large un-water-jacketed area and thus raises the problem of heat-dissipation; for piston temperatures are intimately related to the many questions of lubrication and general engine operation. Important among the functions of the piston or the top-ring temperatures are both gasoline and oil economy, and the objective in any consideration of these factors should be the proper transfer of heat from the head to the rings and the skirt and to the cylinder walls. The successful accomplishment of this transfer makes possible an increase in compression and thus more efficient combustion without detonation.

As an example of design based upon these principles, Mr. Horning showed his aluminum piston with special twin-rings fashioned so as to present large contacting surfaces, most essential to rapid heat-dissipation. The piston itself was characterized by ample wall sections properly distributed, thus allowing for satisfactory heat-transfer. It was stated that with this type a compression-ratio of 4.7 to 1 can be used and further that the "punishment" does not become localized in the top ring as in certain other designs. Freedom from slapping and leakage were mentioned as other advantages. It was also asserted that inasmuch as no important oil relief through holes under the lower ring is present, the dilution problem is minimized and wear is reduced by the absence of metal-to-metal contact. The design does not permit of such high mechanical efficiency, but this was said to be more than offset by the possibility of higher compression and better combustion efficiency. Oil consumption was claimed to be greatly reduced, and the speaker reported that a run of 45 hr. was required for the newer type to show a burnt-oil deposit equal to that accumulated by the ordinary piston in 2 hr.

Induction and Distribution

Many past attempts to improve the performance of internal-combustion engines have dealt primarily with increased sizes of carbureters, manifolds and valves. In Mr. Horning's opinion these efforts have been misdirected in a measure and should have been concentrated to a greater extent on the combustion-chamber where the energy is taken from the fuel. However, he emphasized the fact that the problems of manifolding and distribution are very important in connection with the treatment of the combustion-chamber. In the newer type of engine described, efforts have been made to get correct and equal amounts of air and fuel, properly mixed, into each of the cylinders; this is brought in at a reasonably cool temperature. A small venturi is used, and a relatively small intake-manifold gives a high velocity and satisfactory atomization of the intake charge. In this connection, it is true that volumetric efficiency is sacrificed to a certain extent in the attempt to attain high compression. The importance of having as high a compression as practicable was brought out by the statement that the theoretical thermal efficiency increases from 36 per cent at a compression-ratio of 3 to 1 to 70 per cent for a ratio of 10 to 1.

The Combustion-Chamber

One of the most important factors upon which the design depends is the proper amount of turbulence within the combustion-chamber. This turbulence which results in better and more rapid burning of the charge is attained by the head attributed to Mr. Ricardo. On the theory that the turbulence resulting from the high-velocity intake-charge is counteracted to a considerable extent by the secondary or parasitic turbulence or eddies on the cylinder walls before it becomes most effective, Mr. Ricardo endeavored to obtain turbulence at the time of ignition when it could best assist in rapid burning. This result he accomplished by shaping the cylinder-head so as to leave as small a clearance as possible at one side of the cylinder and then by gradually enlarging the clearance space properly toward the opposite side to the point where the spark-plug is located. Thus, when the piston comes up on the compression stroke, most of the charge is rapidly squeezed out from one side toward the other with the resulting turbulence that is desired. At the proper instant the spark occurs and the charge is fired.

This is followed by the very rapid burning of the charge from ignition to maximum pressure which was claimed to take place with the Ricardo head in an interval from one-half to one-sixth as long as is required for the ordinary types; the time-ratio varying with the conditions of speed. The flame-travel is limited by the proper location of the spark-plug near the center of gravity of the mixture, a very important consideration.

As a result of the more rapid and efficient combustion it is proper to have less spark advance than with ordinary types, and on a speed basis it is found that the advance need not be varied over considerable ranges; the engine takes care of this automatically. Turbulence was accredited with the material reduction of operating temperatures. In the exhaust, this was laid to the elimination of the dead layers near the walls and their after-burning.

In conclusion Mr. Horning stated that with the engine and piston which he described it is possible to use a compression-ratio of 5 to 1 and that fuel consumption of 0.5 lb. per b.hp-hr. can be attained.

Laboratory Tests

In the afternoon before the meeting Mr. Horning and his assistants gave a demonstration of his engine in the Wheeler-Schebler laboratories. Runs were made at several loads and speeds. The compression-ratio of the engine was 4.5 to 1.

In the first test, which was run at full load and 1200 r.p.m., a fuel consumption of 0.57 lb. per b.hp-hr. was obtained. The second test, at full load and 1500 r.p.m., gave the same value, showing that the extra power required to run the engine was just balanced by the more efficient combustion at the higher speed. Another test, at half load and 1500 r.p.m. gave a consumption of 0.72 lb. per b.hp-hr. This figure would have been improved had the water temperature, 190 deg. fahr., been as high as in the other tests, 210 deg. fahr. At three-quarter load and 1500 r.p.m., 0.62 lb. per b.hp-hr. was the fuel consumption.

It is of interest to note that the performance outlined above was obtained without proper aluminum pistons which would give the best compression and without sufficient time to bring about the best operating conditions. Those in charge deserve great credit for staging the tests when they had had barely sufficient time to mount the engine on the stand and attach a carbureter that was not adjusted to the engine.

Business Meeting

The technical session in the evening was preceded by a dinner and a short business meeting. J. H. Hunt brought up the question, recently raised, of assessing the members within certain zones surrounding Section headquarters $5 per year additional for dues, this amount to be collected by the New York City office and then turned into the Section treasuries to cover the costs of operation. Considerable discussion was raised, and it was finally moved and carried, 13 to 6, that the Indianapolis Section recommend that the New York City office collect additional annual dues from those members situated within certain zones, to be determined by the Council, and that the amount be only sufficient to finance the Section activities properly. It was stated that such action would relieve the local officers of much work and worry and that the organizations would be placed upon a sound financial basis thereby.

Chairman Chandler named the following nominating committee to choose nominees to hold office during the coming year: O. C. Berry, Fred Duesenberg, Howard Marmon, W. G. Wall and George Weidely.

SAN FRANCISCO GROUP MEETS

Some 30 members of the Society residing in the San Francisco district gathered at the Whitecotton Hotel in Berkeley, Cal., for an informal dinner on Jan. 24. Through the courtesy of A. B. Domonoski, associate professor of experimental engineering at the University of California, the members later visited the testing laboratory at the University where L. M. Boelter gave a talk and demonstration on head-lamp illumination and adjustment. He commended the work of the Society and that of the Illuminating Engineering Society on the matter of head-lamp glare.

Members on the Pacific coast are looking forward to a banner meeting that is being planned for the week of the San Francisco Automobile Show in February. Arrangements for this meeting are in the hands of A. A. MacCallum, 115 New Montgomery Street, San Francisco, who should be addressed by members wishing particulars.

AIR-RIDING COMFORT

In the news story of the Dec. 6 meeting of the Detroit section that was printed under this title on p. 93 of the January issue of The Journal, the cuts and the captions used to illustrate this account of the paper presented by J. J. McElroy, chief engineer of the Westinghouse Air Spring Co., were somewhat mixed up. The three cuts used in this account are printed herewith with their proper captions.

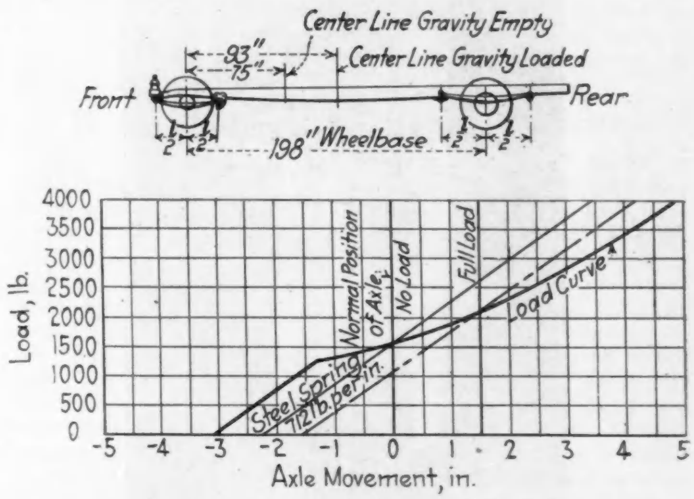


Fig. 1—Typical Air-Steel Spring Load Curve
The Curve Shown Is That of a 3½-In. Air-Spring in Combination with a 712-Lb. Scale Steel Spring Used on the Front End of a Motorbus. The Combination Load-Curve Has a More Flexible Spring Scale in Its Normal Range when Contrasted with the Ordinary Steel Spring. As the Load Increases the Rate of Change of the Spring Scale Increases to the Maximum Shock Load

Schedule of Sections Meetings

FEBRUARY

4—Buffalo Section—Engines for Oil versus Oil for Engines—L. H. Pomeroy and A. Ludlow Clayden
6—Minneapolis Section—Steps in the Development of a Light Racing Car—J. L. Larson. Application of Fire Apparatus to Standard Chassis—F. P. Smith
7—Detroit Section—Balancing of Automobile Engines—J. E. Schipper. Four-Cylinder Engine Mounting—L. C. Freeman
8—Mid-West Section—Symposium On Automotive Engineering Progress
12—New England Section—Hotel Highland, Springfield, Mass.
14—Metropolitan Section—Relation of Methods of Maintenance to Vehicle Life and Cost of Operation—R. E. Plimpton
Indiana Section—Air-Cooled Engine Performance—C. P. Grimes. Engineering—Dean Potter
18—Cleveland Section—Pyroxylin Enamels for Automobiles
21—Detroit Section—Balancing of Automobile Parts—Production Discussion

MARCH

17—Cleveland Section—Traffic Control—Major Mark Ireland

APRIL

3—Detroit Section—Chassis Lubrication—Fred H. Gleason

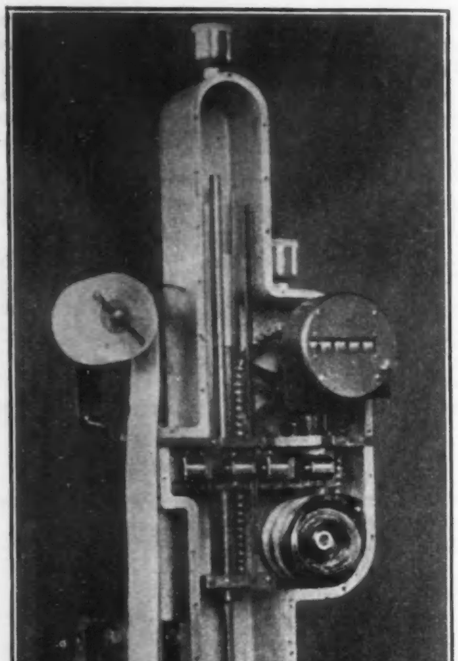


FIG. 2—MECHANICAL AXLE-MOVEMENT RECORDER WITH THE OUTSIDE COVER-PLATE REMOVED

This Instrument Measures the Total Travel of the Axle in Feet, the Number of Axle Movements, the Number of Times the Axle Passes The Normal Rest Line, the Actual Travel in Feet above the Normal Rest Line and the Corresponding Travel Below. Five Different Phases of Axle Movement Are Automatically Recorded by This Instrument

FIG. 4—THE MECHANICAL AXLE-MOVEMENT RECORDER AS IT IS ATTACHED TO THE FRONT END OF A CAR PREPARATORY TO MAKING A TEST RUN

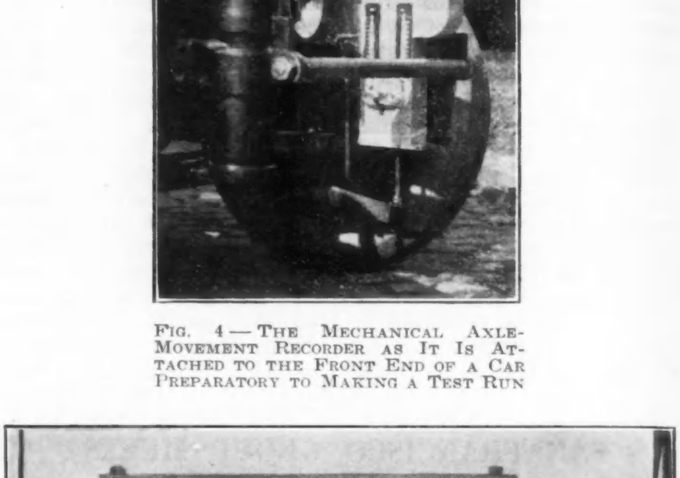


FIG. 5—THE VERTICAL VIBRATION-RECORDER THAT OPERATES ON THE SAME PRINCIPLE AS A PEDOMETER

In Its Present State of Development the Device Is Considered Reliable Enough To Give Fair Average Comparisons as to the Relative Merits of Different Spring-Suspensions. The Recording Apparatus of a Pedometer Is Impelled by an Oscillating Weight Supported by a Lever Arm, the Entire Mass Being Nearly Counterbalanced by an Adjustable Spiral Spring

Fig. 4, showing the mechanical axle-movement recorder illustrated in Fig. 2 as it is attached to the car ready for a test run, and Fig. 5, illustrating the vertical vibration-recorder, the principal parts of which are shown in Fig. 3, were recently received from the author and are included to give the members an idea of how the two instruments actually look.

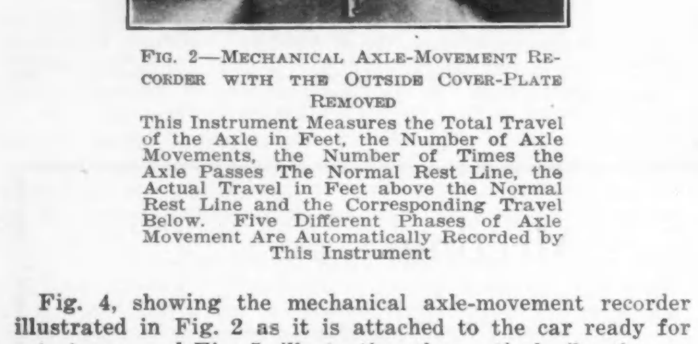


FIG. 3—A VERTICAL VIBRATION-RECORDER

The Weight *w* Is 85 Per Cent Spring-Suspended through the Radius-Arm *a* That Is Held by a Flat Spiral Spring Located Alongside the Friction Drum *b*. The Drum Floats on Ball Bearings at the Center and Is Actuated by Pawls to the Radius-Arm So That It Moves Only in One Direction. The Tape Is Pulled by the Rotation of the Friction Drum as the Weight Goes Down; Each Throw Is Recorded on the Tape as It Passes under the Weight Which Is Equipped with a Pin That Perforates the Tape

BALANCE OF AUTOMOBILE ENGINES

Automobile-engine balance will be discussed from three angles at the meeting of the Detroit Section on Feb. 7. This meeting will be devoted to design and technical phases of the engine-balance problem. J. E. Schipper will review the problem from the standpoint of the trained critic. L. C. Freeman will tell how inherent unbalance of four-cylinder engines can be counteracted by mounting the engine properly. O. C. Kreis will discuss the fundamental causes of periodic vibration in crankshafts, giving some new theories on how the periods can be controlled. J. G. Vincent and A. A. Bull have agreed to participate in the discussion.

Production problems met in balancing automobile engines will be the subject of the production meeting of the Section on Feb. 21. Announcement of the speakers for this session will be made through the Detroit Section's publication *The Detroit Journal of the S. A. E.*

All Detroit Section meetings are held in the General Motors Building and are preceded by an informal supper at 6.30 P.M. The meeting program opens promptly at 8 o'clock.

MINNEAPOLIS DISCUSSES SERVICE

Automobile service was the subject of the meeting of the Minneapolis Section held on Jan. 2. Over 30 members were present and enjoyed talks by Fred I. Cochran, service manager of the Northwestern Nash Motors Co., on Service-Station Problems; Harry Merriman, of the Pence Automobile Co., on Service Problems from the Customer's Standpoint, and J. Harrison, service manager of the Anthony Motors, the Packard distributor, on Shop Efficiency. The three talks and the discussion of them indicated a commendation on the part of service managers to please the motor-car owners and disclosed an increasing tendency to improve shop efficiency.

The next meeting of the Minneapolis Section will be held on Feb. 6 at the Manufacturers Club, starting at 8 o'clock. Two talks will be given. J. L. Larson, engineer of the Owen Motor Sales Co., St. Paul, will discuss Steps in Development of a Light Racing Car, and F. P. Smith, engineer of the Northern Fire Apparatus Co., will give an interesting talk on Application of Fire Apparatus to Standard Chassis.

IMPROVEMENTS IN RUBBER MANUFACTURE

Successful Transportation of Virgin Latex Opens Way for Better Rubber Products

Rubber latex and methods of procuring, transporting and utilizing it formed the subject of an interesting paper read by B. J. Lemon of the United States Rubber Co. before the January meeting of the Dayton Section. Mr. Lemon opened his talk by commenting on the importance and value of commercial research. He said that it is the conviction of the United States Rubber Co. that research laboratories which function properly pay big dividends.

Rubber latex is a milky fluid that flows from the rubber tree when it is tapped. It is the source of all crude rubber. the juice is not tree sap; sap flows through the wood, but latex is contained in the inner bark. As rubber has become more uniform and of better quality, attention has been focused on eliminating some of the steps in rubber preparation that are expensive and in some ways detrimental. This started research on the problem of the direct use of rubber latex. As it comes from the rubber tree, latex is made up of about 30 per cent rubber, 4 per cent mineral salts, proteins and sugar, and 66 per cent water. The minute rubber globules are suspended in a watery liquid. This physical makeup of the latex drops surrounded by or suspended in water classifies it chemically as a colloidal substance.

Rubber latex, like milk, shows complicated physical and chemical properties of the highest degree. Its stability as a colloid is subject to disturbance by very slight changes; acidity leads to coagulation of the rubber; time or churning leads to separation of the rubber. In either case, the latex as such is destroyed.

Transportation of Latex Is Now Practicable

The latest and most important accomplishment in the rubber industry is the preserving of rubber milk or latex so that it can be transported from the plantations in steamers and tank cars to the factories in this Country. There it is used in its liquid form or by extracting the rubber from it by a special spray process. The search for a chemical to prevent coagulation of the latex in transportation was a long one. Hundreds of chemicals, including acids, break down the latex and precipitate the rubber. Other substances will preserve the physical and chemical balance of the latex, among which ammonia is the most practical thus far discovered. The advantages of low cost, availability and ease of transportation of ammonia were important factors leading to its selection. It is effective in small concentration and does not disturb the physical makeup or the color of the latex. Ammonia is also an antiseptic or deterrent of bacterial growth, a quality that retards the natural development of acid-forming bacteria in latex.

How Rubber Latex Is Used

When the virgin latex arrives from the tropics, it is a uniform solution that flows and wets like water, holding 30 per cent of rubber which is uncontaminated by acids, smoke, bark or dirt. Artificial rubber-cement containing as little as 10 per cent of rubber is like molasses. Experiments to date indicate that a natural absorption characteristic exists between latex and cotton which gives the former a penetrating fluidity that has not been equalled by dissolving coagulated rubber in organic solvents. A greater percentage of rubber can be soaked into fabrics as latex than as artificial cement, and moreover it is a rubber of higher tensile-strength and better quality. In addition, latex-treated fabric possesses advantages over cement-treated fabric in that the soluble natural constituents of the rubber are carried by latex into the cords, whereas with rubber cement, most of these substances are lost in the coagulation process of making crude rubber.

Rubber Coagulated from Latex by Spraying

Instead of coagulating rubber from latex by smoke or chemicals, latex is now sprayed as a snow-white mist into superheated air. Thus the water is driven out and pure rubber remains. In this process, latex is run in a small stream onto a revolving horizontal disc from which it is thrown as an umbrella-shaped spray into the current of heated air. The rubber globules are dried almost instantly and settle as a creamy-white spongy mass at the bottom of the chamber. The sponge rubber is then compressed into a baler and is ready for use. Latex spray rubber has many advantages. It vulcanizes faster and ages slower than conventional crude rubber. Its three features, high tensile-strength, slow aging and rapid curing, are of great economic importance and they will lead to many interesting developments in the manufacture of rubber products in the future.

SERVICE AND REPAIRS NOT ANALOGOUS

Every purchaser of automotive equipment expects a square deal and satisfaction. This square deal and satisfaction may be likened to the seat of a three-legged stool which depends upon the stoutness of its three legs for its stability. These three legs are; first, the maker's responsibility; second, the dealer's responsibility; and third, the owner's responsibility. The maker must build his products right; the dealer must sell his products right and service them adequately; and the owner must treat the product right. This was the key-note of the talk on automotive service given by Arthur B. Cumner, general service manager of the Autocar Co., before the January meeting of the New England Section in Boston.

Mr. Cumner remarked that service is what we do for the owner; maintenance, what we do for the car. If we pass into a shop marked "repair" we know we have something to pay for; but, if we pass into a shop marked "service," we are expecting to get something for nothing. It is Mr. Cumner's belief that the word service should be removed from the doors of all repair shops. He also believes that the dealer should adopt as far as possible the maintenance plan laid down by the manufacturer of the product he sells. The manufacturer knows his product better than the dealer and is in a better position to prepare the best plan for maintaining it. It is time that the designer of automotive products become familiar with the tools in general use in the average service-station so that he can design cars which can be repaired or adjusted without requiring special tools that cost a considerable sum of money.

There are five fundamental principles to follow in proper maintenance of automotive vehicles:

(1) Regular and intelligent lubrication

(*Concluded on p. 262*)

Crankcase Drainage Facility and Oil-Sump Capacity

By T. A. WAERNER[1]

DAYTON SERVICE MEETING PAPER

MENTION is made of extensive campaigns to educate automobile dealers and the motoring public into a realization that clean, undiluted oil must be used in engine crankcases to attain satisfactory engine performance, and abstracts cited from letters answering a questionnaire indicate an agreement that better crankcase drainage facilities should be provided generally, so that drainage will become more frequent and less difficult.

An analogy to the composition and the combustion of present motor-fuel is found in the fuels needed to start a furnace fire; shavings, kindling-wood, cord-wood and pea, nut, stove and egg-size coal, the match being analogous to the ignition spark and the other fuels corresponding to the different grades of combustible in the gasoline. This is used to illustrate how unburned fuels are left in the cylinders and dilute the oil later. The damaging effects of crankcase-oil dilution are discussed, an analysis of crankcase oil-sump capacities is presented, and two standard oil-sump capacities are recommended.

THE three items I wish to mention as a means of reducing the percentages of fuel dilution are (*a*) greater accessibility for draining engine-lubricating oil, making it possible for the average owner to do this job himself in sections of the Country where crankcase service is not obtainable; (*b*) greater accessibility for cleaning vital parts before reassembling, after draining used lubricating-oil, and (*c*) more adequate consideration of crankcase oil-sump design.

Regarding (*a*), the service departments of prominent automobile factories have conducted extensive campaigns to educate their dealers to impress upon their customers the fact that a clean, undiluted oil must be employed to obtain satisfactory operation of the engine. These service departments have devoted much space in instruction books and have written many service letters to recommend that the lubricating-oil be drained at various intervals in summer and in winter; but, although these campaigns have resulted in immeasurable benefits to the automobile owner, I doubt if the desired results have been achieved as satisfactorily as they would have been if the engines had been designed with a view to making the drainage of lubricating-oil a bit easier, not only for the owner who looks after his own car but for the service-stations that are called upon to perform this work. As regards proper lubrication, I know of no other matter that is as necessary at this time as arranging engines so that they can be drained properly.

I was never more forcefully impressed with the shortcomings of the present-day designs for draining crankcases conveniently than when, in 1920, I purchased a second-hand automobile. About the first thing I did was to get some of the best oil obtainable; then I started to drain the crankcase about 10 o'clock one Sunday morning. I had to get under the car, remove the pan, try to find a suitable wrench to remove a plug that was stuck and, after I was through with cleaning-up after the job, it was time for dinner. When I had thought this matter over, I sent the following letter to the members of the Society of Automotive Engineers:

> It is generally conceded in the automotive industry that, to care for internal-combustion engines properly, the lubricating oil must be drained at certain intervals and the crankcase filled with fresh oil. If the owner of an automobile undertakes to do this himself, it is necessary for him to get under the car to unscrew the plug placed in the bottom of the crankcase. The operation is inconvenient, dirty and laborious. Private owners, transportation managers and service men all look forward, we believe, to having a conveniently located suitable oil-drain incorporated in future engine designs, a device arranged so that all oil, including the oil left in the connecting-rod troughs, can be drained as easily as it was poured. May we have your thoughts on the matter?

We received some 2400 replies to this letter, all of which agreed that such a campaign as we were conducting was well worthwhile; almost without exception, all agreed that a suitable oil-drain operable from under the hood should be incorporated in all future engine designs. Abstracts from a few of the letters received are as follows:

> We believe your suggestion regarding the location of an accessible oil-drain in future engine designs is very much to the point, and it certainly meets with our approval. We do not locate an oil-drain as per your recommendation at present, but we certainly will not fail to consider it in future designs.
>
> We are lacking, in this respect, as are the majority of other manufacturers, but I thoroughly agree that some method must be developed to make the draining of the oil a simple matter; otherwise the ordinary user will neglect it. We have this in mind and will correct it on our own cars just as soon as we possibly can.
>
> The easy draining of a crankcase is essential, but you must realize that it is difficult to put these ideas into effect on account of having dies made up and a large stock of oil-pans on hand that are made with the ordinary drain-plug. At several of our plants, as soon as the supply is used up and commitments taken care of, we will no doubt seriously consider making the change which you have recommended.
>
> We believe your idea to be a good one and it has been incorporated in some of our engines. There was just one criticism; that is, that the oil-drainer is too easily left open. However, I do not believe that amounts to very much and, in all probability, we will incorporate a more accessible drainer in our future engines.

All the replies to our circular letter were given to the Standards Department of the Society and a meeting of the Engine Division was held in Cleveland in September, 1921, to consider the standardization of a suitable draining device and make suggestions for locations. As a result, during the 1922 Semi-Annual Meeting, the Standards Committee decided that no definite type of oil-drain should be standardized; but the recommendation was made that a suitable oil-drain of ample dimensions operable from under the hood should be recommended.

[1] M.S.A.E.—Engineer, Tide Water Oil Co., New York City.

I know of less than half a dozen automobile builders whose engines are designed so that they can be drained conveniently, and these companies represent only a small part of automobile production.

Motor-Fuels

Before I mention additional items as a means of reducing dilution, let me give a practical illustration of motor-fuels in general, so that you can realize that we cannot at present hope for such a marked improvement in motor-fuels as will combat the evil of crankcase-oil dilution. The structure of gasoline is well known to most of you but, to get a full realization of the extent to which you may be called upon in the future to make improvements in engine designs that will meet various fuels, let me give you a word-picture of the physical characteristics of gasoline, how dilution is effected, its causes and how certain gasolines will dilute the lubricating-oil to different degrees, as compared with other gasolines of the same specific-gravity.

All gasolines are derived from crude petroleum, but the characteristics of crude oils obtained in different localities vary widely. Therefore, gasolines made from them do not resemble each other closely although they look very much alike to the layman. We know that water starts to boil at 212 deg. fahr. and boils at this temperature until the end. But gasoline is a physical blend of hydrocarbons, all of which boil at different temperatures and can form an explosive mixture with air when atomized suitably. With present carburetion methods, gasoline must contain a sufficient quantity of volatile constituents; that is, light gasolines that will form an explosive mixture with air very readily and start the engine in this way. The function performed by these light gasolines in the gasoline is the same as that of shavings in starting a fire.

To make the illustrations clear so as to represent the actual explosions of the fuel mixture in the explosion chambers, let us consider a number of different fuels that are necessary to start a furnace fire properly; that is, shavings, kindling-wood, cord-wood and pea, nut, stove and egg-size coal. The flame from the match represents the ignition spark; it sets fire to the shavings that gradually fire the kindling-wood, the cord-wood and so on. The light parts of the gasoline represented by the quality and the quantity of the shavings determine the ease of starting of the engine. The quality and the amounts of the different grades of fuel in the gasoline, represented by the kindling-wood and the cord-wood, indicate the intermediate explosions. In other words, gasoline is a physical blend of hydrocarbons and the fractions boil at different temperatures.

Let us then consider the later period of combustion. The shavings and the kindling-wood have burned-up, the cord-wood is almost consumed, the pea coal and part of the stove coal are burning, but only part of the egg coal is glowing. The egg coal represents the heavy ends of the gasoline; thus, we have an indication of what is left of unburned fuel in the explosion chambers. Part of this unburned fuel cannot be gotten rid of altogether, commercially. On the upward stroke, it is pumped past the pistons and rings into the crankcase oil-sump and dilutes the lubricating-oil. More heat-units exist in kindling-wood than in shavings, more in cord-wood than in kindling-wood, and more in coal than in cord-wood. But to utilize these available heavier fuel units with present carburetion methods, under all conditions of operation of the modern engine, is a problem. It may be understood best when we consider what a rich mixture is necessary to start the engine, this being similar to the amount of shavings necessary to get sufficient power. Under this condition, the intermediate fuels left in the explosion chamber unburned, represented by the furnace fuels cord-wood to coal, find their way into the crankcase and dilute the lubricating-oil to an extent that, after a short operation and under certain conditions, may amount to from 10 to 20 per cent of the engine's oil-sump capacity.

In view of the manner in which unburned fuel reaches the engine's oil-sump and of the detrimental effect this has upon lubrication in general, it is of the utmost importance to consider seriously a mechanical means, to be arranged conveniently in such a way as to invite the automobile owner to do certain things that will be of decided benefit, prolonging the life of the engine as a whole and reducing the general upkeep cost. It is only by reducing the cost of operating automobiles in general that we can hope to increase the number of automobile users, reaching those who today are unable to own automobiles on account chiefly of depreciation and general charges and not initial cost.

In reference to item (*b*), oil consumption is due principally to leakage, evaporation and "cracking." In addition, sediment is formed and road-dust is collected in the oil-sump. Sufficient heat is often developed to make oils crack inside the pistons, resulting in the formation of hard carbon particles that fall to the bottom of the oil-sump, when no protective collecting screens are employed, and clog the oil-sump screen. No convenient way of removing the last-mentioned screen for cleaning is provided on the majority of automobile engines. To get at it and clean it thoroughly, about the only way is to remove the entire oil-pan, a procedure that usually must be carried out at a service-station. Would it not be well to consider, as a universal practice on all designs, arranging the oil-pump screen so as to allow its removal, independent of the oil-pan? In some designs, there is a profusion of oil-leads on the outside of the engine, with numerous fittings that loosen and cause leakage and, in certain cases, a complete drainage.

Damaging Effect of Dilution

In considering the damaging effect on automobile engines of highly fuel-diluted lubricating-oil, let us remember that a mineral lubricating-oil does not have a high affinity for heat but has a tendency to withdraw from an overheated surface. For this reason, a thinner protecting oil-film is present where a thicker oil-film is most needed, the lubricating-oil drawing toward the cooler surface, in this way leaving the hotter surfaces subject to complete withdrawal. Under such conditions, dry spots occur with the resultant evil of scoring. A lubricating-oil diluted with motor-fuel naturally will withdraw or evaporate readily. In fact, since the cylinder walls have an operating temperature above 400 deg. fahr., the evaporation of the fuel-diluted lubricating-oil may be so rapid as to cause a metallic contact between pistons and cylinders over a large area, with a consequent complete seizure of the engine. In view of this, and considering the rubbing surfaces of all other parts of the engine, I believe that any expense to incorporate mechanical means that will reduce the amount of dilution, and devices that will improve present systems of lubrication, is warranted.

Oil-Sump Capacity

Concerning item (*c*), that of consideration of crankcase oil-sump design to reduce percentages of dilution,

I would say that when I sold my car in 1922 I included a 5-gal. can of oil with the car. The new owner drove to a garage to have the crankcase drained. Afterward I saw him driving home. A cloud of smoke was trailing him. I asked him later if he had had the whole 5 gal. of new oil put in. He admitted he had had plenty of oil put in, but it was evident that some must have been drained out; also that the garage man did not know what the capacity of the oil-sump was. We then wrote to all car-builders to get information on crankcase capacities, as we thought it would be of value to the owner and to the garage man to know what the oil-sump capacities of the different engines are. We wanted to incorporate this information in a chart of oil recommendations.

An analysis of the replies shows that crankcase oil-sump capacities vary from 4 qt. on many types of engine to 14 qt. on some others. As an example, two representative types of six-cylinder engines of about the same piston displacement requires 5 qt. for one and 14 qt. for the other. Would it not be convenient for all concerned to standardize on two capacities, one for four-cylinder engines and the other for six and eight-cylinder engines? Perhaps the Standards Committee of the Society could, in time, get builders to agree on certain capacities in future designs.

Regarding dilution in these engines having different oil-sump capacities, pouring $1\frac{1}{2}$ qt. of kerosene into an engine having a 14-qt. oil-sump capacity causes about a 10-per cent dilution. The same amount added to an engine with a 5-qt. oil-sump capacity represents nearly 30-per cent dilution. Considering that the average amount of oil in the sump, during operation, about half-fills it, these comparative percentages become all the more significant.

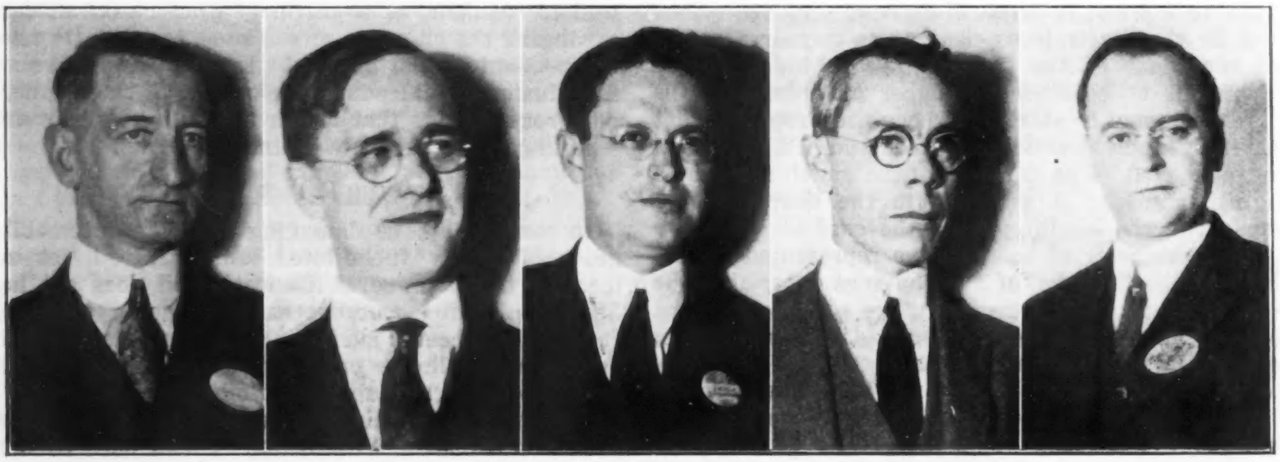
MEETINGS OF THE SOCIETY

(Concluded from p. 259)

(2) Regular tightening of loose nuts and bolts
(3) Care never to overload or overspeed
(4) Regular expert inspection
(5) Attention to little repairs before they become big

The consistent application of these fundamentals to car-maintenance methods will positively protect the automobile owner's investment. Fully 75 per cent. of the average upkeep of motor cars is caused by the first three items listed.

Several members contributed interesting comments to the discussion. One of these was a representative of the Boston Fire Department who said that motorization has made the Fire Department more efficient. It has speeded-up their arrival at the fires and enabled them to extinguish them to better advantage. Motorization has also made living conditions in the fire houses better by eliminating the unsanitary environment of a stable and the work of caring for the horses.



H. E. DERR International Harvester — G. C. MATHER Paige — J. H. HUNT General Motors Research — H. E. MAYNARD Maxwell — R. K. JACK Oldsmobile

PROMINENT ENGINEERS PRESENT AT THE ANNUAL MEETING

Applicants *for* Membership

The applications for membership received between Dec. 15, 1923 and Jan. 15, 1924, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly

ALDUNATE, ALFREDO, 815 Colonia Road, *Elizabeth, N. J.*

ARRONET, HERBERT A, inspector, Ordnance Field Service, *Camp Meade, Md.*

BABB, C. L., student, Purdue University, *Lafayette, Ind.*

BAILEY, H. P., assistant treasurer, Warner & Swasey Co., *Flint, Mich.*

BALLENTINE, R. W., district manager of sales, Timken Roller Bearing Co., *Canton, Ohio.*

BARRY, JAMES J. W., mechanical engineer, Federal Rubber Co., *Boston.*

BERGE, LOUIS B., master mechanic, A. C. Spark Plug Co., *Flint, Mich.*

BIRKIN, K. W., superintendent of motor vehicles, Sinclair Refining Co., *Chicago.*

BOICOURT, J. C., student, Purdue University, *Lafayette, Ind.*

CAMERON, ALBERT BOYERS, student, Purdue University, *Lafayette, Ind.*

CHAPPUIS, JOHN M., mechanical engineer, 310 West 89th Street, *New York City.*

CHU, LYNN, aeronautical engineer, Cox-Klemin Aircraft Corporation, *Long Island City, N. Y.*

COOPER, HOWARD, assistant supervising engineer, Sinclair Refining Co., *Chicago.*

CROCKETT, CLARENCE VAIL, JR., student, Purdue University, *Lafayette, Ind.*

CROSSLAND, R. O., student, Purdue University, *Lafayette, Ind.*

CURTIS, LESLIE F., chief engineer, American Bosch Magneto Corporation, *Springfield, Mass.*

DALTON, HERBERT, tool and die designer, General Motors Truck Co., *Pontiac, Mich.*

DANIELS, H. A., manager of Cleveland office, Baush Machine Tool Co., *Springfield, Mass.*

GUTTERSON, WILDER, secretary and general manager, Rubber Shock Insulator Co., *New York City.*

HEENEY, TERRENCE J. C., assistant cable engineer, Northern Electric Co., Ltd., *Montreal.*

HESS, DONALD P., general manager, Timken Roller Bearing Co., *Columbus, Ohio.*

HOLTHE, THORLEIF, engineer, Aeromarine Plane & Motor Co., *Keyport, N. J.*

KALLMEYER, B. J., student, Purdue University, *Lafayette, Ind.*

LAUGHLIN, LEDLIE I., district sales manager, Jones & Laughlin Steel Corporation, *Buffalo.*

LAWSON, GUSTAF A., sales manager, Jamestown Car Parts Mfg. Co., Inc., *Jamestown, N. Y.*

LEAMON, WILLAM G., consulting chemist, 30 Linden Avenue, *Newark, Ohio.*

LOCKINOUR, CLIFFORD M., student, Purdue University, *Lafayette, Ind.*

MCALLISTER, A. J., student, Purdue University, *Lafayette, Ind.*

MARKS, CECIL STANLEY, mechanical engineer, *Sea Point, South Africa.*

MAXWELL, LLOYD, automobile advertiser, Maxwell-McLaughlin & Co., *Chicago.*

MEYER, JOHN LOUIS, student, Purdue University, *Lafayette, Ind.*

MONG, K. C., student, Purdue University, *Lafayette, Ind.*

MONIHAN, JOHN GUY, special representative, Newport News Shipbuilding & Dry Dock Co., *Detroit.*

MUZZY, MORRIS J., student, University of Michigan, *Ann Arbor, Mich.*

NICHOLSON, EARLE J., draftsman, H. H. Franklin Mfg. Co., *Syracuse, N. Y.*

PARKER, F. B., student, Purdue University, *Lafayette, Ind.*

PARRISH, W. J., vice-president, Standard Steam Corporation, *St. Louis.*

PERROT, HENRI, consulting engineer, 177 Boulevard Pereire, *Paris, France.*

RAABE, HENRY E. A., mechanical engineer, private experimental engineering in Jersey City, N. J. and *Bridgeport, Conn.*

RHEIN, L. R., body engineer, Ford Motor Co., *Dearborn, Mich.*

ROGERS, MASON T., president, Burton-Rogers Co., *Boston.*

SAUNDERS, FRED LIDDELL, tester, International Motor Co., *Plainfield, N. J.*

SCHULTZ, ROY WILSON, manager, B. F. Goodrich Rubber Co., *Cleveland.*

SEARIGHT, T. P., H. M. Hobson, Ltd., *London, S. W., England.*

SMITH, TEMPLE C., engineer, American Telephone & Telegraph Co., *New York City.*

SPEIR, GODFREY B., engineer, Vacuum Oil Co., *New York City.*

THULMAN, ROBERT KELLY, 2493 Valentine Avenue, *New York City.*

TRAVIS, THOMAS H., superintendent and production manager, *Stamford, Conn.*

VAWTER, GEORGE W., assistant general manager, Capitol Overland Co., *Indianapolis.*

VERNET, SERGIUS, chief engineer, Motorcraft Engine Corporation, *New York City.*

VORAS, E., student, Purdue University, *Lafayette, Ind.*

WALLIS, MARVIN, superintendent, Elgin Street Sweeper Co., *Elgin, Ill.*

WATKINS, F. L., salesman, Jones & Lamson Machine Co., *Springfield, Vt.*

WHEELER, HENRY E., draftsman, Goodyear Tire & Rubber Co., *Akron, Ohio.*

WHITE, GERALD TAYLOR, editor, Rudder Publishing Co., *New York City.*

YEAGER, LEO RICHEY, general manager, Yeager Tilt-O-Lite Co., *Columbus, Ohio.*

ZUBATY, JOSEPH, experimental engineer, A. C. Spark Plug Co., *Flint, Mich.*

ZWALD, ADOLPH, chief engineer, Hood Tractor Co., *Seattle, Wash.*

Applicants *Qualified*

The following applicants have qualified for admission to the Society between Dec. 10, 1923, and Jan. 10, 1924. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member; (E S) Enrolled Student.

ALLEY, JOHN H. (E S) student, Georgia School of Technology, *Atlanta, Ga.*, (mail) 416 Hemphill Avenue.

ANDERSEN, CARL C. (A) assistant comptroller, Republic Motor Truck Co., Alma, Mich., (mail) care of American Express Co., Haymarket, *London, S. W., England.*

ANDERSON, CHARLES S. (E S) student, New York University, *New York City*, (mail) 2079 Wiegand Place.

BARNETT, JOHN H. (A) advertising manager, Robert H. Hassler, Inc., 1545 Naomi Street, *Indianapolis.*

BRATTON, ANDRAL (E S) student, Georgia School of Technology, *Atlanta, Ga.*, (mail) 42 West North Avenue.

DUNLAP, GEORGE A. (M) draftsman, Fisher Body Corporation, *Detroit*, (mail) 914 Calvert Avenue.

EBERHARDT, FRED ROSS (M) manager of gear department, Newark Gear Cutting Machine Co., *Newark, N. J.*, (mail) 37 Huntington Terrace.

ELLINGHAM, FRANCIS W. (A) superintendent, Holt Mfg. Co., *Stockton, Cal.*

GILLIES, GORDON C. (A) manager of tachometer division, Elgin National Watch Co., 86 East Randolph Street, *Chicago.*

GILPIN, BENJAMIN H. (M) factory manager, Driggs Mfg. Corporation, *New Haven, Conn.*, (mail) 669 Elm Street.

GRANGER, HENRY R. (E S) student, Cornell University, *Ithaca, N. Y.*, (mail) 315 Dryden Road.

GRANT, J. M. (M) assistant service manager, White Co., Long Island City, N. Y., (mail) 9 McIntosh Street, *East Elmhurst, N. Y.*

HOWARD, HAROLD F. (A) sales division service manager, Wire Wheel Corporation of America, 1700 Elmwood Avenue, *Buffalo, N. Y.*

JANSSON, AXEL J. (M) designer, International Motor Co., New York City, (mail) 47 Fairbanks Street, *Hillside, N. J.*

KAHRS, OTTO (F M) engineer, Raadhusgaten 1, *Kristiania, Norway.*

KELLEHER, R. J. (A) European representative, North East Service, Inc., Rochester, N. Y., (mail) 10 Rue Labie, *Paris XVII^e, France.*

LANDSTAD, HANS (F M) works manager, Morris Motors, Ltd., *Cowley near Oxford, England*, (mail) 102 Divinity Road.

NORBERG, G. HAROLD (M) superintendent, Huck Axle Corporation, *Chicago*, (mail) 4909 Erie Street.

SHERE, A. T. (J) mechanical superintendent and designing engineer, California Transit Co., *Oakland, Cal.*, (mail) 1018 Madison Street.

SIMPSON, ANDREW (M) instructor, Swarthmore College, Swarthmore, Pa., (mail) 1311 Main Street, *Darby, Pa.*

SMITH, FRED C. (A) national director of automotive trade schools, International Committee, Y. M. C. A., 347 Madison Avenue, *New York City.*

STEWART, WARREN A. (E S) student, Georgia School of Technology, *Atlanta, Ga.*, (mail) 120 Arden Avenue.

SWOBODA, HERMAN ALFRED (E S) student, Stevens Institute of Technology, *Hoboken, N. J.*, (mail) 523 River Terrace.

WALTER, EDFORD MILTON (M) mechanical engineer, General Motors Research Corporation, *Dayton, Ohio.*

WATKINS, BENJAMIN E. (E S) student, Georgia School of Technology, *Atlanta, Ga.*, (mail) 46 McLendon Avenue.

WRIGHT, PAUL D. (E S) student, Ohio State University, *Columbus, Ohio*, (mail) 48 15th Avenue.